This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LANE MEDICAL LIBRARY STANFORD
J111 .H21 3 STOR
A text-book of pathology systematic & pr
24503448618

21B

A TEXT-BOOK

OF

PATHOLOGY

SYSTEMATIC & PRACTICAL

BY

D. J. HAMILTON, M.B., F.R.C.S.E., F.R.S.E.
PROFESSOR OF PATHOLOGY, UNIVERSITY OF ABERDEEN

COPIOUSLY ILLUSTRATED

VOL. II

PART II, PAGES 515 TO END

LANE MEDICAL LIBRARY
13367
SAN FRANCISCO

London
MACMILLAN AND CO.
AND NEW YORK
1894
B

All rights reserved

H21
v. 2, pt. 2
1894

CHAPTER LXXIV

THE INTESTINE

SECRETIONS AND EXCRETIONS POURED INTO IT.

848. MUCH less is known of intestinal indigestion than of the corresponding condition in the stomach. The reason of this is that it is impossible to withdraw the contents for purposes of examination.

Intestinal Ferments.

849. There appear to be several ferments contained in the succus entericus of the small intestine. One of the chief of them has the property of converting *maltose into grape-sugar.* Another transforms *cane-sugar into invert-sugar,* a mixture of equal parts grape-sugar or dextrose and fruit-sugar or lævulose. It does so by causing the cane-sugar to absorb water.

$$2C_{12}H_{22}O_{11} + 2H_2O = C_{12}H_{24}O_{12} + C_{12}H_{24}O_{12}$$

Saccharose. Water. Dextrose. Lævulose.

Invert-sugar is therefore a more highly hydrated substance than cane-sugar.

There also appears to be a weak *diastatic ferment* and *one which acts slightly upon proteids.* It has also been asserted that the juice of the small intestine *emulsifies and partly breaks up fats.* This, however, is disputed.

Little is known of the effect of diminished secretion of the succus entericus.

Pancreatic Ferments.

850. The pancreatic secretion is particularly rich in ferments. It used formerly to be thought that the various functions subserved by it were due to a single ferment. That, as is now well known, is not the case. The secretion from the pancreas possesses several ferments, each having a special action. There is, firstly, *a proteid solvent named trypsin* (pancreatic pepsin); secondly, there is *pancreatic diastase* alike in its action with that found in the saliva; thirdly, according to Roberts, there is a *milk-curdling ferment;* and fourthly, there is a ferment which emulsifies and partially saponifies fats.

The use of the pancreatic secretion is mainly to supplement and complete the hydrolytic processes commenced in the mouth and stomach. The starch which escapes being converted into maltose by the saliva has a second opportunity of being transformed by it in the small intestine; and proteid matters which are not thoroughly peptonised in the stomach are again subjected to the action of the pancreatic pepsin known as trypsin.

The fats are not only emulsified in the small intestine, but a large proportion of them is decomposed, whereby the glycerine and fatty acids are separated. A similar fat-decomposing function apparently exists, but in minor degree, as already described (p. 472), in the secretion of the stomach. Bernard (No. 455, ii. p. 346) held that the cause of the emulsification was the presence of a ferment in the pancreatic secretion. Roberts, however, doubts whether this is so (No. 454, p. 72). He thinks the liberated fatty acids of themselves are sufficient to emulsify the neutral fats.

In the digestion of proteids within the stomach it is seldom that the hydrolysis is carried further than the formation of peptone. The pancreatic pepsin or trypsin is capable of breaking up the peptone still further into a number of hydration products. Among these may be mentioned leucin, tyrosin, naphthylamine, and indol.

The pancreatic ferments are active only in an alkaline medium. The acid chyme after passing into the duodenum soon loses its acidity; it is neutralised by the alkaline secretions of the small intestine and pancreas.

Uses of the Bile.

851. These are usually said to be: (1) the neutralisation of the acid chyme and the precipitation of propeptones and pepsin; (2) the emulsification of fats; (3) the aiding in absorption, particularly of fats; (4) the excitation of peristaltic action in the intestine and the lubrication of fæcal matters; (5) the acting as an antiseptic. According to Copeman and Winston, its influence as an antiseptic is feebler than is generally supposed.

Harley (No. 438, p. 18) maintains that bile emulsifies and saponifies the fatty acids, while pancreatic juice not only possesses this action, but also reacts similarly upon neutral fats. Quite apart from its emulsifying properties, however, bile seems to possess the power of aiding fatty matters in passing through an animal membrane. Harley (*loc. cit.* p. 17) says that when an albuminous liquid mixed with oil and contained in a loop of intestine is suspended in water, the oil does not pass through the coats of the intestine. When bile is added to the mixture, however, it finds its way outwards even when free from pressure. The oil comes through in the form of a soapy-looking substance.

Ox, sheep, and horse bile, according to Hofmeister (No. 49, 1886, i. p. 145), has a powerful influence in *hydrating starch* with formation of sugar; while dog's or pig's bile possesses this property either not at all or only to a minor extent. None of the various biles employed by him have the property of dissolving or splitting up albumin. The bile of the horse, ox, or sheep possesses a feeble power of splitting up neutral fats, an action which does not seem to be inherent in pig's or dog's bile. All biles, he says, emulsify fats, the strongest being that of the dog. A lactic acid ferment, as a rule, is present in the bile, or develops in it on standing. The action of gastric juice is annulled by the presence of bile (1 c.c. bile in 11 c.c. artificial gastric juice).

When the bile duct is obstructed the absorption of the products of digestion of starch or albumin does not seem to suffer to any appreciable extent (Mueller, No. 49, 1887, ii. p. 277). The absorption of fats, however, is markedly diminished. From 55 to 78·5 per cent of the fat taken as food passes off in the fæces. The presence of needle-shaped fat crystals in the fæces is an indication of disturbed fat absorption. The more easily melted, the more readily are the fats absorbed.

In a woman suffering from a biliary fistula made for occlusion of the common bile duct, Copeman and Winston (No. 179, x. 1889, p. 213) found that there never was any constipation, although the fæces were quite free from bile pigment. The fæcal matter contained a large proportion of fat once rather more than 18 per cent, showing that in the absence of bile the pancreatic juice is unable to complete the digestion and absorption of fats. The amount of undigested proteid matter, however, was comparatively slight.

There were never any symptoms of dyspepsia and the patient had a voracious appetite, an observation in accordance with what is noticed in dogs suffering from biliary fistula.

A similar case observed by Paton and Balfour (No. 599, iii. 1891, p. 191) in main supports the above statements.

Bile and the Colour of the Fæces.

852. The colour of human bile when first secreted is not golden-red, but a pale olive green. The colouring matter, according to Copeman and Winston (No. 179, x. 1889, p. 213), is biliverdin. The colour, however, as shown by *post-mortem* examination, rapidly changes after the bile passes into the gall-bladder. The biliverdin becomes reduced to bilirubin. Bilirubin is present in fresh human bile only in small quantity.

The colouring matter of the human fæces is derived partly from bile, partly from the food consumed. The bile element is due to *stercobilin*, a substance supposed to be identical in composition with hydrobilirubin. On a *rich animal diet* the dejecta become of a dark brown colour; and on a *mixed regimen* the colour is brownish-yellow—the colour, that is to say, which may be regarded as healthy in the case of Man. During a *dietary of fruit* the reduction of biliverdin to hydrobilirubin does not take place. Hence, it is said, the fæcal matter may have a green colour. This colour is not explicable on the theory of the presence of chlorophyll.

THE VEGETABLE MICRO-ORGANISMS OF THE ALIMENTARY CANAL.

853. Pasteur has long held that vegetable microbes play an important rôle in natural digestion. It is alleged that where the pancreatic duct is obstructed, part of the work done by the pancreatic secretion may be overtaken by the organisms present in the contents of the intestine.

The meconium three to seven hours after birth is sterile, or at most a few cocci are obtainable from it by cultivation. They usually take the form of diplococci. In about eighteen hours after birth, however, bacteria make their appearance in abundance (Escherich, No. 439, 1886, p. 18).

The attempt made by Vignal (No. 4, x. 1887, p. 286) and others to isolate and enumerate those found in the mouth and intestinal canal seems almost hopeless, so abundant are the varieties. Certain of them are destroyed by the gastric juice, but others pass the stomach and begin to fructify when they get into the neutral contents of the intestine. They evidently contribute a part here in rendering certain of the ingesta soluble and capable of being absorbed. Their number comes up to something like twenty millions per décigramme of fæcal matter (Vignal).

Brieger (No. 187, viii. p. 306, and ix. p. 1) found *in normal fæces*, among others, two organisms of note on account of their chemical properties. One of these is like the pneumococcus and has the property of converting grape-sugar and cane-sugar into ethylic alcohol; the other grows in circles upon gelatine plates and converts grape-sugar into propionic acid.

Stahl made out that there were as many as twenty different kinds of organism present in normal fæces; while Bienstock (No. 11, i. 1883, p. 609), on the other hand, believed he had proved that the essential bacteria of the intestine are neither micrococci, bacterium termo, nor spirochaetæ, but purely and simply bacilli. The cause of this, he supposed, lay in the destructive influence of the acid secretion of the stomach upon all such organisms unless in the condition of spores. The spores can pass the stomach and redevelop into bacilli in the intestine.

Escherich (No. 439, 1886, p. 111) finds that the prevalence of any particular organism varies with the diet. Thus, those present in the alimentary canal of the dog differed materially according to whether it was fed on milk or on meat.[1]

He disagrees with Bienstock altogether as to the alleged presence of bacilli alone in the intestine. By careful plate-cultures he was enabled to isolate many other forms.

INTESTINAL CATARRH.

854. **Anatomical Appearances.**—The mucosa is red from hyperæmia and is covered with dense masses of tough, tenacious mucus which, if the bowel be empty, serve to glue its surfaces partially together. It is seldom that the condition becomes muco-purulent. The part of the bowel most often affected seems to be either the *large intestine* or the *lower part of the small*. There is a prevalent opinion that it is a common disease of the *duodenum* and that the catarrhal secretion and the hyperæmic swelling of the mucosa tend to occlude the opening of the duct and to occasion an obstructive jaundice (see *Jaundice*).

The minuter changes of the mucous membrane, like those of the catarrhal stomach, have not been well studied, owing greatly to the macerated and often half-digested state in which the mucosa is found after death. Intestinal mucus is normally secreted from the epithelium covering the mucosa. Its cells become distended with it and are correspondingly transparent; they are converted into chalice cells when the mucus is discharged. The quantity of mucus formed by these in catarrh must be much greater than in health. The immediate cause is probably the underlying congestion. The epithelial cells may also be shed.

---

[1] He gives at p. 108 of above work a list of those micro-organisms which he found in meconium from infants of different ages under a milk diet. The list is too long to transcribe.

It is said that catarrh is liable to be accompanied by follicular ulceration. Croupous enteritis, however, is a commoner cause of this. A chronic catarrh with such ulceration is also alleged to occasion a *fibrous new formation* between the crypts of Lieberkuhn (Ziegler).

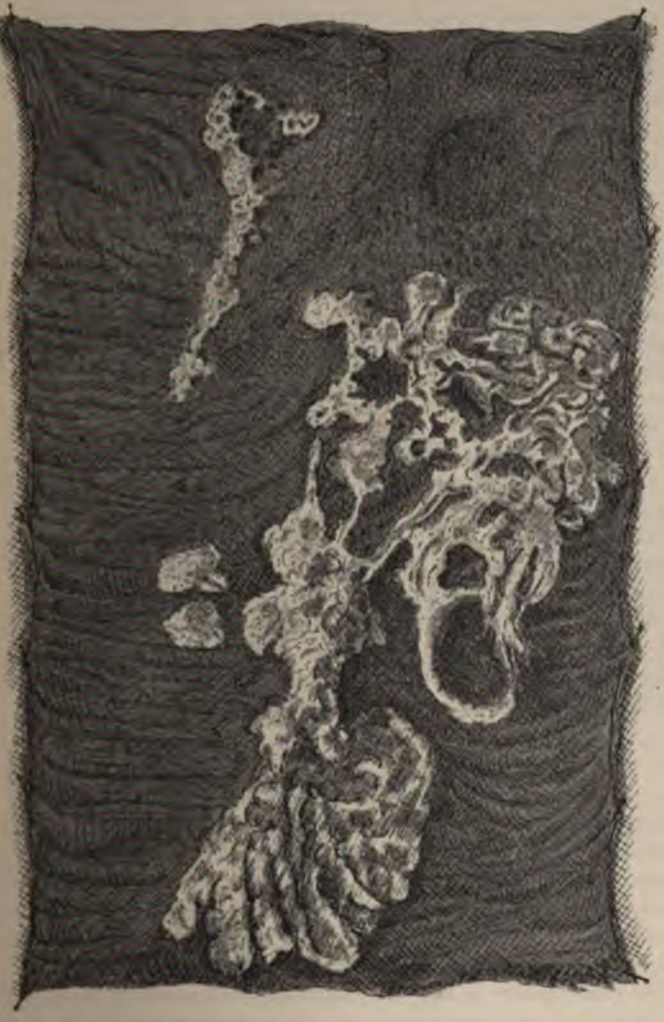


FIG. 399.—CATARRH OF INTESTINE SHOWING THE MASSES OF TENACIOUS MUCUS ADHERING TO THE SURFACE.

MEMBRANOUS CATARRH.

855. There is a peculiar condition, apparently of catarrh, in which gelatinous casts are voided *per anum*. Women in middle life sometimes habitually pass gelatinous membrane-like casts of the intestine. The casts are perfectly homogeneous and transparent and have none of the appearance of croupous membranes. What the condition of the bowel associated with them is, has never been recorded.

ACUTE PERFORATING ULCER OF DUODENUM.

856. This appears to be analogous in all respects to the disease bearing a like name in the stomach. It has the same sharply-punched-out appearance, is frequently multiple, and by no means seldom ends fatally by perforating. One of the constant primary effects of the disease, as also in the case of the gastric ulcer, is copious **hæmorrhage**. The hæmorrhage manifests itself by **melæna**. It is in the first portion of the duodenum that the ulcer or ulcers are found, almost one and a half to two inches from the pylorus; they tend to fuse together. They are sometimes associated with similar ulcers in the stomach. They cicatrise in the same way as the gastric ulcer; the head of the pancreas is often utilised as a stop-gap and support to the floor.

Their pathology, so far as is known, is alike with that of the perforating ulcer of the stomach. There are at least two proteid solvents in the duodenum, namely, gastric pepsin and pancreatic trypsin, but seeing that the first part of the organ is the region in which the ulcer is almost always found, it is more likely that the solution takes place through the agency of the gastric pepsin before it has undergone precipitation by contact with bile.

Acute Duodenal Ulcer after Burns and Scalds.

857. It was long ago pointed out by Dupuytren (No. 459) that the stomach and intestine are liable to inflammation after the immediate danger of a burn of the skin is past. He did not, however, suspect that the duodenum was the part most liable to suffer. Since then so many cases (see *Bibliog.*) have been put on record of acute perforating duodenal ulcer following upon extensive burns and scalds that the coincidence of the two conditions can scarcely be regarded as fortuitous.

In the year 1842 Curling (No. 34, xxv. 1842, p. 260) recorded ten instances in which he had found an acute duodenal ulcer associated with burns of the skin and two in which there was acute duodenitis. In three out of the above ten cases death occurred from perforation. The perforation is sometimes very small, at other times as large as a shilling. The ulcers are sometimes multiple. According to Curling, the ulceration takes place, as a rule, immediately opposite the head of the pancreas, and hence renders the occurrence of hæmorrhage frequent and severe from the arteria-pancreatica-duodenalis being opened into. It is commonest in young subjects; the eldest in Curling's cases was twenty-eight, while the ages of the others ranged between three and nineteen years.

DILATATION OF DUODENUM.

858. The duodenum sometimes reaches an astonishing size, so much so that it comes to resemble a second stomach. The cause is usually a **stricture** at its lower end. Wernich (No. 13, l. 1870, p. 138) relates a case where there was a constriction both at the upper and lower ends. In some instances there may be a **diverticular pouch** leading off from the main cavity. The stricture is usually caused by a cancerous tumour, but sometimes by a cicatricial band or cord-like old adhesion. Even where the cancerous tumour infiltrates universally as much as the lower two-thirds of the viscus, the dilatation, cancerous part included, may be extreme.

DISEASES OF THE FOLLICULAR TISSUE.

859. The follicular tissue of the gastro-intestinal tract is very abundant. It consists of little lymph-gland-like bodies situated in the mucous membrane and extending deeply into the submucosa. The so-called *Peyer's patches* are colonies of these. The follicular tissue is most abundant in the lower half of the ileum where the Peyer's patches are also found. Isolated follicles, however, are met with here and there in the stomach and throughout the whole intestine.

Under certain conditions this follicular tissue becomes swollen and hypertrophied, so that the individual glands project above the level of the mucosa. It does not always follow, however, that the grouped and isolated follicles are simultaneously swollen, and there must, therefore, be some difference in their function. In typhoid fever, which affects this follicular tissue more constantly than any other disease, they have become enlarged and almost simultaneously so, but even here the one is at times much more at fault than the other. In septic diseases, more especially septic disease in which the poisonous products of the wound are swallowed, the solitary glands of the ileum will be found enlarged often to the exclusion of the Peyer's patches.

There is this difference, however, between the typhoid and almost all other simple enlargements of the follicular tissue, namely, that it is only in the former that sloughing tends to follow upon the infiltration.

The superficial erosions so often met with on the mucosa of the colon are often called *follicular* ulcers. It is questionable, however, whether these all arise in connection with the lymph-follicles. They are usually too superficial to be accounted for in this way. They are more like localised eczematous spots, if one may so characterise them, than true ulcers following upon a deep-seated infiltration of the glands in the mucosa.

It is a remarkable and as yet unexplained fact that the lymph-follicles of the **ileum**, which apparently seem to be nothing more than little lymph-glands connected with the abundant plexus of lymphatics in the intestinal wall, are much more apt to become sympathetically enlarged in disease than those of the gastro-intestinal tract elsewhere. Thus the tubercular, typhoid, and ordinary septic poisons all tend to fix upon the glands of the ileum in preference to those in the stomach, duodenum, jejunum, or colon.

It is said by Pavy that the Peyer's patches and solitary follicles in the pup become enlarged and more vascular under a *diet of cane-sugar*.

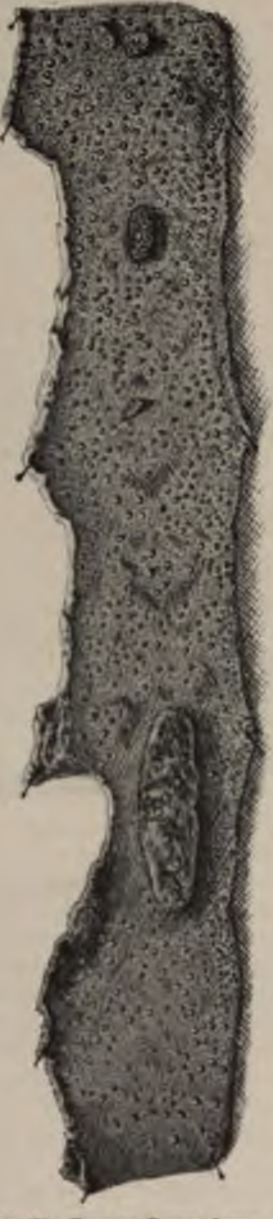


Fig. 400.—Typhoid Fever, Ileum of Child, showing the Infiltration of the Peyer's Patches and Solitary Follicles.

Typhoid Fever.

860. In typhoid fever the chief and primary lesion is located in the intestine and mostly in the ileum. The stomach, duodenum, and jejunum are rarely affected, and the large intestine not nearly so commonly as the ileum, although oftener than the jejunum. **The lower end of the ileum** is the head-centre of the lesion.

Anatomical Description.—The *follicular glands* are the seat of it, and, as before mentioned, both the isolated and agminated glands are affected. These glands enlarge and project visibly from the mucosa. The infiltration is not particularly hard, not so hard as that of a commencing intestinal tubercle.

The Peyer's patches have a gray colour and occasionally a little hyperæmia is noticed around them, but not always. Sometimes the infiltration of a patch is partial, so that its middle third or one end is elevated while the rest of the patch is unaltered.

The cause of the swelling is mainly a *small round cell infiltration* of the glands alone (Fig. 401), or of these with their immediate surroundings. The cellular infiltration is probably of an inflammatory nature, and is caused by the presence of the typhoid bacillus.

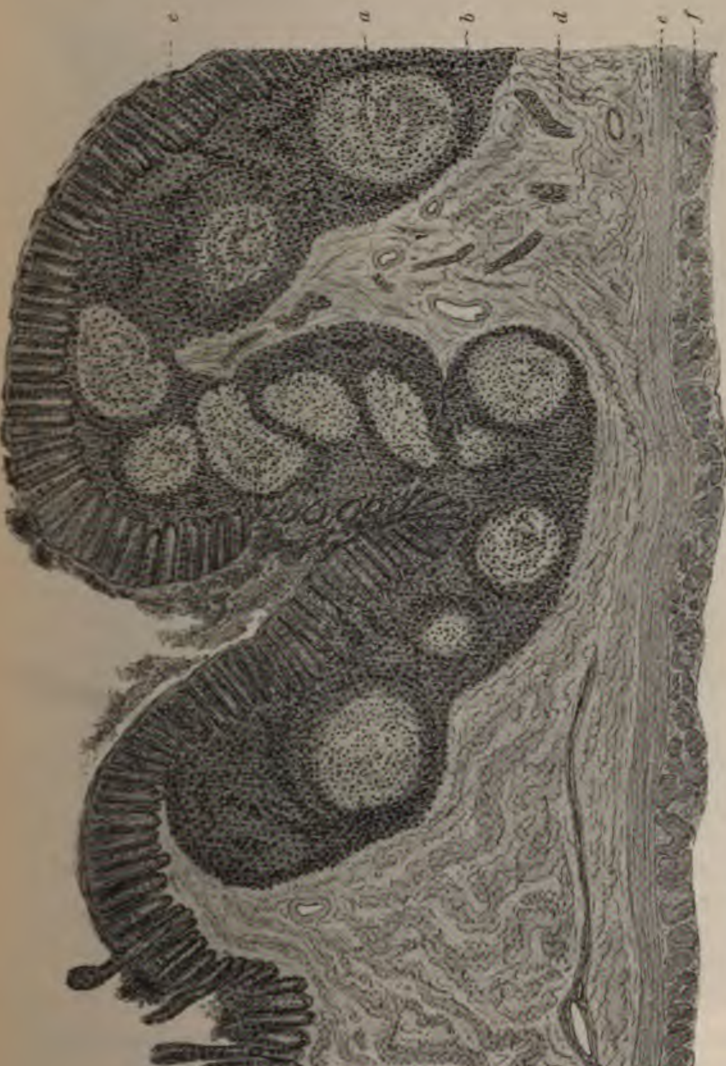


FIG. 401.—TYPHOID FEVER, PERPENDICULAR SECTION, ILEUM OF CHILD (× 50 DIAMS.)

(*a*) Infiltrated Peyer's patch showing enlarged follicles; (*b*) cellular infiltration around the follicles; (*c*) mucous membrane; (*d*) submucosa; (*e*) transverse muscular coat; (*f*) longitudinal muscular coat (Perosmic Acid and Farrants' Sol.)

In from ten days to a fortnight the infiltrated glands *slough* and leave a characteristic ulcer. Previous to the separation of the slough the gland tissue has necrosed. Its cells assume a faint and ill-defined outline, become very granular and ultimately many of them fatty. The gland is detached in shreddy masses.

The ulcer which is left has the following characters:—If a Peyer's patch be the seat of it the shape is usually *oval*, but if the disintegration has been partial the shape may be almost quite *round*. *The long axis* is in the long axis of the intestine. *The floor* as a rule is smooth, and is made up of the exposed muscularis. The sloughing

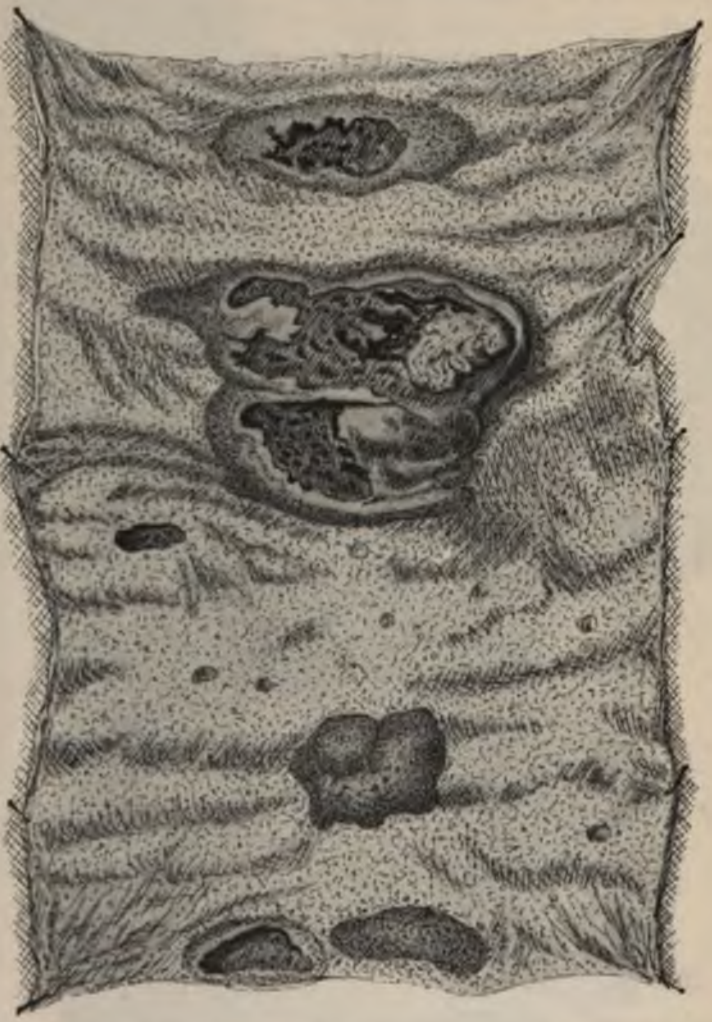


FIG. 402.—TYPHOID FEVER, ILEUM OF ADULT, SHOWING THE SLOUGHY AND INFILTRATED PATCHES.

has destroyed the mucosa and submucosa. If the disintegration, however, has been partial, shaggy masses of necrosed tissue may still be left adherent and give the floor a rough aspect. The edges are more or less unattached and float when placed in water. In some cases the surroundings may be congested, but, as in the earlier stage of the lesion, this, after death at least, may be entirely wanting.

The serous coat of the bowel, so long as perforation has been avoided, shows little alteration. There is an absence of the stellate cicatrix-like patch with tubercles in it characteristic of intestinal tuberculosis.

The disintegration seldom goes farther than the muscularis. One of the great dangers, however, to be feared is that it extends more deeply and occasions a **perforation.** The perforation varies in size from a mere point to a ragged sloughy opening half an inch in diameter. Fæcal matter has escaped from it; but the perforation may become temporarily closed by effusion of lymph, with or without adhesion of a loop of bowel or of some neighbouring viscus; so that on exposing the abdomen the aperture may be found with difficulty.

Unless the escape of fæcal matter is limited by surrounding adhesions it usually causes death from **peritonitis** within a few hours. If confined to the vicinity of the perforation, however, the immediately fatal issue may for long be warded off, and an **abscess** form in the pouch of peritoneum at the point of escape. This may discharge externally and recovery take place. The chances even here, however, are that the individual will succumb to an intercurrent attack of general peritonitis or to septic poisoning.

The isolated or solitary follicles go through the stages of infiltration and sloughing alike with the Peyer's patches. The resulting ulcers remain discrete and have not the same tendency to perforate as those located within the patches.

The lesion within the **large intestine** consists in an infiltration and ulceration of these solitary follicles sometimes to such an extent that they look from their projection and shape like small polypi. When this is the case similar infiltrated follicles will probably also be found in parts of the small intestine other than the ileum. And even in the **stomach** itself corresponding nodular projections may be noticed rarely, generally with an eroded and hæmorrhagic depression in their centres. It is seldom that the lesion of the large intestine extends to the rectum.

The appearance of the **caput cæcum** in some instances resembles that of a malignant sore throat. The entire mucous membrane is in a sloughy condition. The slough is ash-gray coloured or is stained yellow or olive-green with bile. Remnants of fæcal matter may be seen adherent to the shreddy surface.

Healing of the Ulcers.—The ulcers heal without cicatricial contraction. Stricture of the bowel from typhoid is a thing almost unheard of. The surface is said to become covered with fine granulations over which the epithelium ultimately spreads. It is rare, however, to meet with the disease in this granulating stage, so much so that the healing of the ulcer by ordinary granulation might reasonably be doubted. It seems rather as if the floor of the ulcer simply underwent a process of cleaning, that a thin layer of embryonic cicatricial tissue came to cover it, and that epithelium in course of time spread over this. The layer of cicatrix resulting from the further organisation of the young cicatrix is so delicate that it does not tend to constrict the channel; it simply induces a slight depression on the mucosa.

The cicatrix usually becomes pigmented; the pigment is distributed in small dark gray or black points; and the outlines of the missing Peyer's patches are thus permanently demarcated.

Hæmorrhagic Typhoid.—In certain cases of typhoid there is a great tendency to hæmorrhage almost throughout the entire body. The skin, conjunctivæ, tonsil, larynx, serous membranes, stomach, bowel, etc., are all the seat of purpura-like hæmorrhages, and hæmorrhagic infarction masses may be found in the lung.

Glandular Enlargement.—In practically every case of typhoid the *mesenteric glands* will be found more or less enlarged. Where there is a hæmorrhagic tendency the enlargement may be so general that the case may be mistaken for one of (acute) Hodgkin's disease. Even the glands at the bend of the elbow may be distinctly felt through the skin in such a case; and those of the groin, axilla, and neck can be felt aggregated in masses or running in chains. The mesenteric glands are sometimes enlarged to such an extent as to occasion an appearance resembling that of a lobulated tumour.

The lymphadenoid tissue of the tonsils and tongue appears to suffer equally with the lymph-glands elsewhere. The tonsils are swollen to the size of small walnuts, and the accessory tonsils at the root of the tongue project as globose masses. The fact that the tonsils become swollen in an early stage of the disease may lead to the disease being confounded with diphtheria. Many of the usual symptoms, such as diarrhœa, may be absent, a state of matters which is very misleading. The temperature, even, may be subnormal. Indeed there is perhaps no disease in which the classical phenomena may fail so frequently as typhoid; it is often only at the *post-mortem* examination that the true nature of the case is revealed.

Pyæmic Tendency.—Hæmorrhagic cases, more especially where combined with excessive glandular enlargement, have a pyæmic tendency. Huge infarctions are sometimes found in the spleen, which are on the point of breaking down into pyæmic-like abscesses. Similar deposits may be seen in the lungs.

Condition of the other Organs.—*A lobular or patchy pneumonia*, usually of a sub-croupous type and with a tendency to form pyæmic infarcts, is a common pulmonary complication. The spleen is increased in size and somewhat pulpy, and infarction-like masses, as before mentioned, may be found in it. The *liver* may be much enlarged, apparently from fatty infiltration around the sublobular vein. There are often minute deposits within it; these are described elsewhere (see *Liver*). The epithelium of the *convoluted tubes of the kidneys* may present a swollen and granular appearance. This occasions some amount of enlargement of the cortex. The *thin muscles of the abdominal wall* and the *adductors of the thighs* undergo a colloid change (see Sect. 135), which gives them a pallid fish-muscle-like aspect.

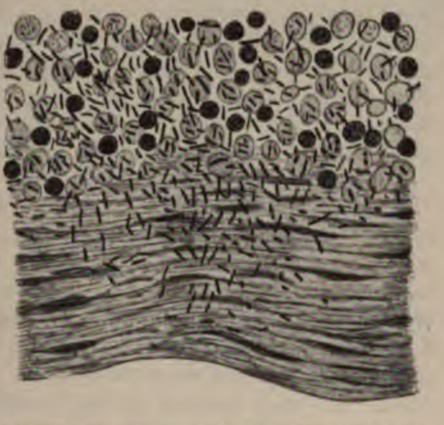


FIG. 403.—TYPHOID INFILTRATION OF INTESTINE (ZEISS HOMOG. IMM. $\frac{1}{12}$; OCULAR NO. 4; ×950 DIAMS.)

The upper part of the figure represents the submucosa infiltrated with the typhoid bacillus; the lower part the muscularis. The bacillus in the mucosa is partly contained within the small round cells infiltrating the part. (Stained in warm methyl-violet solution; washed out in alcohol; clarified in oil of cloves; and mounted in balsam).

The contents of the bowel are usually bright yellow in colour and liquid in consistence; but it cannot be too strongly emphasised that the absence of these features must not be held as excluding the possibility of typhoid fever. The contents of the large intestine are sometimes hard and scybalous.

The Typhoid Microphyte.

Morphology.—The discovery of what is now regarded by every one as the specific organism of typhoid, appears to have been made about the same time by Klebs (No. 104, xii. 1880, p. 231; xiii. 1881, p. 389), Eberth (No. 13, lxxxi. 1880, p. 58; *Ibid.* lxxxiii. 1881, p. 486), and Koch (No. 44, i. 1881). To Eberth, probably, chief credit is due. He not only described the morphology of the organism accurately, but also indicated how it spreads throughout the body, the time at which it is most abundant, and many other points of essential interest.

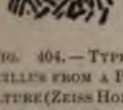


FIG. 404.—TYPHOID BACILLUS FROM A PURE CULTURE (ZEISS HOMOG. IMM. $\frac{1}{12}$; ×950 DIAMS.; stained in Fuchsin).

The organism in question is a *short rod* (Fig. 404) whose description closely corresponds to what used to be called "bacterium termo." It is from 2 to 3 μ. long and 0·7 to 0·9 broad—that is to say, it is from a fourth to a third the length of the long axis of a coloured blood-corpuscle; and about three times as long as broad. In old typhoid infiltrations of organs *thread forms* can also sometimes be detected (Klebs). The ends of the bacillus are rounded; and in the centre of the rod a *clear space* can often be seen, due apparently to retraction of the protoplasm to the two poles. This must not be mistaken for a spore. When cultivated, the bacillus, it is said, does sometimes develop a *spore;* it is located at one end (Gaffky, No. 44, ii. 1884; *also*, Eng. transl., N. Syd. Soc. 1886, p. 221). Nevertheless, several observers deny that typhoid ever produces true spores. When suspended in a drop culture the organism exhibits lively snake-like movements due to lateral flagella.

Staining.—The typhoid bacillus is somewhat difficult to stain. It decolorises by *Gram's method*, but if sections containing it are allowed to remain, previous to staining, for ten minutes in a $\frac{1}{5}$ per cent solution of corrosive sublimate, they retain the colour (Woodhead, No. 588, p. 195). They can be stained in *Loeffler's methylene blue*, composed of one volume of saturated alcoholic solution of methylene blue in three volumes of a 1-10,000 solution of potash. They can also be stained in *Ziehl-Neelsen's solution of fuchsin* (see vol. i. p. 136). Kuhne's method is to place the section first in a saturated solution of oxalic acid, wash, and stain with methylene blue dissolved in a 1 per cent solution of ammonium carbonate. The different solutions are the better of being warmed before use.

Artificial Culture.—It grows readily on a number of different media. One of the most characteristic cultures is that obtained on *nutritive gelatine*. A surface growth on this does not appear before the second or third day. It slowly assumes the character of a delicate grayish-coloured film of almost equal thickness throughout (see Coloured Plate). The lower end of the culture is rounded and outspread while the margins are indented. A puncture inoculation is limited to the track of the needle, and becomes slightly brown-coloured in from fifteen to twenty days. The typhoid organism does not liquefy the gelatine.

Although the growth is retarded by the addition of a small percentage of carbolic acid to the medium, it is not entirely prohibited by it (Eberth). In carbolised gelatine, for instance, the colonies do not appear until the fourth or fifth day instead of upon the second or third.

Grown upon media coloured with aniline dyes, it gradually absorbs the colour so that the medium becomes decolorised. Fuchsin gélose kept at 39° C. is most suitable.

The organism also thrives readily upon *gélose* and *potato*. On potato it cannot be recognised with the naked eye even where the culture is luxuriant. The only indication of its presence is an appearance of moistness of the surface. The acidity of the potato appears to encourage the growth; the organism throws out an acid not an alkaline secretion. The most favourable *temperature* is from 25 to 35° C.

The **spores** resist a temperature of 90° but are killed at one of

FIG. 491.—BACILLUS OF TYPHOID FEVER. Surface-culture on peptone-gelatine. The growth takes the form of a pale gray film. Its margin is indented, and the lower end tends to spread out in a spatula-like manner. (See page 528.)

FIG. 492.—KOCH'S SPIRILLUM OF ASIATIC CHOLERA. Puncture-culture on peptone gelatine. Notice the bell-like character of the upper part of the area of liquefaction. (See page 550.)

FIG. 493.—THE FINKLER-PRIOR SPIRILLUM. Puncture-culture on peptone-gelatine. There is the same bell-like area of liquefaction as in that of Asiatic cholera, but the liquefaction proceeds more rapidly, and later on forms a funnel-like cone. (See page 550.)

FIG. 494.—METCHNIKOFF'S SPIRILLUM. Puncture-culture on peptone-gelatine. The bell-like area of liquefaction is less well marked than in the two foregoing. (See page 550.)

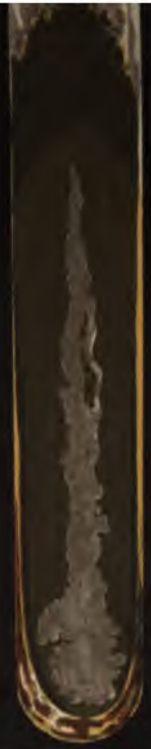


Fig. 491.

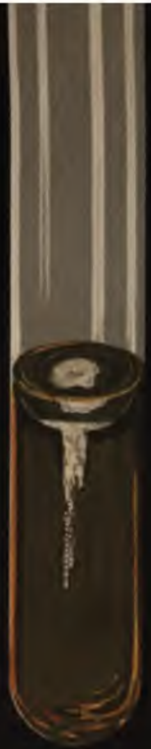


Fig. 492.

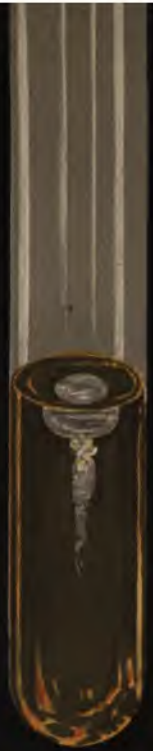


Fig. 493.

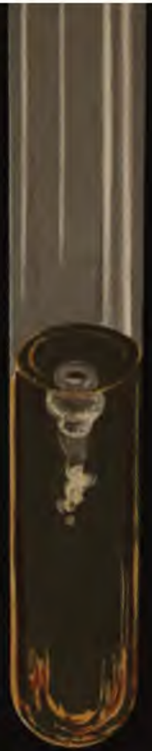


Fig. 494.

R. & R. Clark.
Edinburgh

100° C. The best temperature for the potato growth is from 38° to 40° C. Cultures preserve their vitality for long when dried, probably owing to their having developed spores. At comparatively low temperatures the bacillus, even when sown upon potato, usually fails to spore. At about 30° to 40° C., however, spores are invariably seen in the bacilli on the third or fourth day. They are always at the extremities. The lowest limit at which it will spore appears to be 20° C. At a summer temperature it spores comparatively freely and on various media.

When cultivated the bacillus not only develops spores but grows out into long **threads.**

It thrives readily upon **milk.** Upon sterilised **drinking water** Wolffhügel and Riedel (No. 603, i. 1886, p. 455) found that the organism not only retained its vitality but continued to multiply. It is probable that the disease is disseminated chiefly through these two articles of a dietary. It is difficult, however, to separate it from drinking water.

Distribution.—Within the **sloughs** on the intestine the typhoid bacilli are mixed up with numbers of others which are incidental to the intestinal contents and have nothing to do with the causation of the disease. In the follicular tissue which has undergone proliferation, however, an almost pure culture of the organism may be found. It lies among the lymph-cells and is easily recognised.

The **mesenteric glands** show it almost as abundantly, and masses of it may be detected within the liver, spleen, and kidneys with great regularity; more rarely within the blood-vessels of other organs. It is not easily found within the blood itself. It has been alleged to proliferate in the body after death.

They are much less numerous in the **dejecta,** but, as shown originally by Pfeiffer (No. 11, iv. 1886, p. 706), they are not absent. The typhoid bacillus seems to differ from many others, such as that of cholera asiatica, in the fact that it does not fructify liberally within the contents of the intestine. Its seat of growth is the follicular tissue of the intestinal wall and the blood- and lymph-vessels of distant organs. Its presence within the discharged intestinal contents is to be explained more by its being thrown off accidentally from the intestinal wall than by its reproducing itself to any great extent within the contents. The two great media by which the disease is communicated, nevertheless, are the *fæcal discharges* and the *urine.*

The bacilli are more abundant during the first and second than towards the end of the third and during the fourth week of the disease (Eberth, No. 13, lxxxi. 1880, p. 70).

Poisonous Secretion.—Brieger has alleged that the organism secretes a toxin (typhotoxin) which he has been enabled to isolate. It is secreted only in small quantity, and is occasionally present in the urine when albuminous and when the kidney is infected with the organism.

Inoculation.—Most attempts to inoculate the microphyte upon the lower animals have failed. There is no animal which apparently takes human typhoid. The pig suffers from a disease which, in the locality and nature of the intestinal lesion accompanying it, resembles that of Man. The pig, however, when fed on typhoid dejecta, does not fall a victim to typhoid fever. Chantemesse and Widal (No. 423, ii. 1888, p. 54) allege that they have conferred the disease upon white mice by inoculation. The bacillus was taken from the human spleen and sown for three days on peptonised bouillon at a temperature of 37° C. Four drops were injected into the peritoneum. In thirty-six hours all the mice employed were dead. The intestine was found to be filled with diarrhœal liquid and the spleen was enlarged. The intestine, they state, was in a condition alike with that of human typhoid. The spleen and the medulla of bone contained typhoid bacilli. A sterilised and filtered culture of typhoid bacilli injected into the abdomen renders the mouse immune.

Cygnaeus (No. 492, vii. 1890, p. 375) also alleges that he has conveyed typhoid from Man to animals such as the dog, rabbit, and mouse, through the medium of pure cultures upon potato. The cultures were administered by the mouth, by intravenous, intraperitoneal, or intraduodenal injection, or by inhalation. The lesions were very much the same as in typhoid.

PIG TYPHOID.

861. Under this designation apparently several diseases of the pig have been confounded on account of their all being accompanied by a measly eruption on the skin. The various diseases which have led to this disordered classification are chiefly what are known as Rouget du porc, Mal rouge, Rougeole du porc, Érysipèle du porc, Rothlauf, Swine fever, Schweinseuche, Swine plague, Hog cholera, etc. According to Macé (No. 584) these titles include three distinct and separable affections—namely, (1) Rouget du porc, (2) Pneumo-enteritis of the pig, and (3) Pig cholera.

Rouget du Porc.—Irregular spots or patches of a red colour occur upon the skin of the ears, breast, belly, and inner aspect of the thighs. There is also evidence of acute intestinal irritation. After death the spleen is found to be enlarged, congested, and diffluent; the liver and all the lymph-glands are congested; the blood is dark. Pasteur and Thuillier (No. 40, xcv. 1882, p. 1120) have demonstrated a figure of eight (diplococcus) organism in the blood and exudations. They have cultivated it, and have also attenuated it in such a manner as, they say, to provide a vaccine against the disease. The organism remains coloured after Gram's method of decoloration. When inoculated on the pigeon its virulence is increased, upon the rabbit it is decreased. After it has been passed several times through the rabbit the poison is so attenuated for the pig that it conveys the disease in a mild form to that animal, but in such a form as to protect the animal from a future attack of the natural malady.

Pneumo-enteritis of Pig.—This is the disease which in Great Britain goes by the name of **pig-typhoid**. It was for long confounded with the foregoing. It is sometimes called contagious or infectious pneumonia of the pig. It is a highly contagious disease, and most animals affected by it succumb in from ten to thirty days, usually with a fibrinous pneumonia. At other times the lung complication is of secondary importance, in which case the disease manifests itself chiefly in an intestinal lesion.

The lesion of the intestine is most evident in the lower part of the ileum and commencement of the colon. It shows itself in numbers of nux-vomica-seed- or button-like elevations on the mucous membrane. These consist of infiltrated lymphadenoid tissue existing naturally in the mucous membrane. The appearance is very like that of human typhoid, with this exception, that the raised patches have not so much tendency to slough.

The blood, and more particularly the exudation into the lung, contains numerous short bacteria with round extremities, 1 μ. to 2 μ. long by 3 μ. broad. The organism is usually held to be immobile; some say it is slightly mobile. It is generally aerobic and grows most freely in air, but can also develop in an atmosphere deprived of oxygen. Injected into the lung it occasions the disease, accompanied by both the pulmonary and intestinal lesions. It induces a fatal result when injected into the system of rabbits, guinea-pigs, and mice.

Pig Cholera (*peste porcaine*).—This is known in Germany as "Schweinseuche." What is called "American Swine-plague" seems to be alike with ordinary pig-typhoid or pneumo-enteritis.

The microbe characteristic of this disease is a short rod with round extremities. It also occurs in oval or almost round forms. It is always immobile; it does not colour readily with aniline dyes; nor does it liquefy gelatine. The blood contains it.

TUBERCULAR INTESTINE.

862. Tubercle commences either as a disease of the *serous coat* or as one primarily affecting the mucous membrane. In the former case it constitutes part of a general peritoneal tuberculosis; in the latter the disease is almost always a sequela to pulmonary phthisis. In children a primary eruption of tubercle may occasionally be seen upon the mucosa along with a widespread secondary eruption of tubercle throughout the peritoneal cavity. These cases have probably been caused by the consumption of ingesta infected with the tubercle poison.

Tuberculosis arising in the Mucosa.—The pulmonary phthisis (tubercular pneumonia) with which the disease is commonly associated is usually in the excavating or ulcerating stage. The main seat of the disease is the *caput cæcum*; it diminishes in frequency upwards and downwards from this. The projections of the valve show it first; it assumes the character of a nodular deposit with a tendency to ulcerate. The first thing seen is a number of little projections (tubercular lymph-follicles), hard, raised, and frequently yellow at the summit from caseation; they are often widely separated (Fig. 405). They soon begin to ulcerate from the caseous tip softening, and a small volcano-like excavation results. If several of these should lie closely together they tend to fuse, and thus give rise to an ulcer having the following distinctive characters:—

The Ulcer.—The floor (Fig. 405) is formed of the submucosa infiltrated with tubercular nodules and caseous débris; the ulcer seldom presents the regular aspect of the typhoid ulcer; its edges are sinuous, infiltrated, and somewhat hard; they are also slightly undermined,

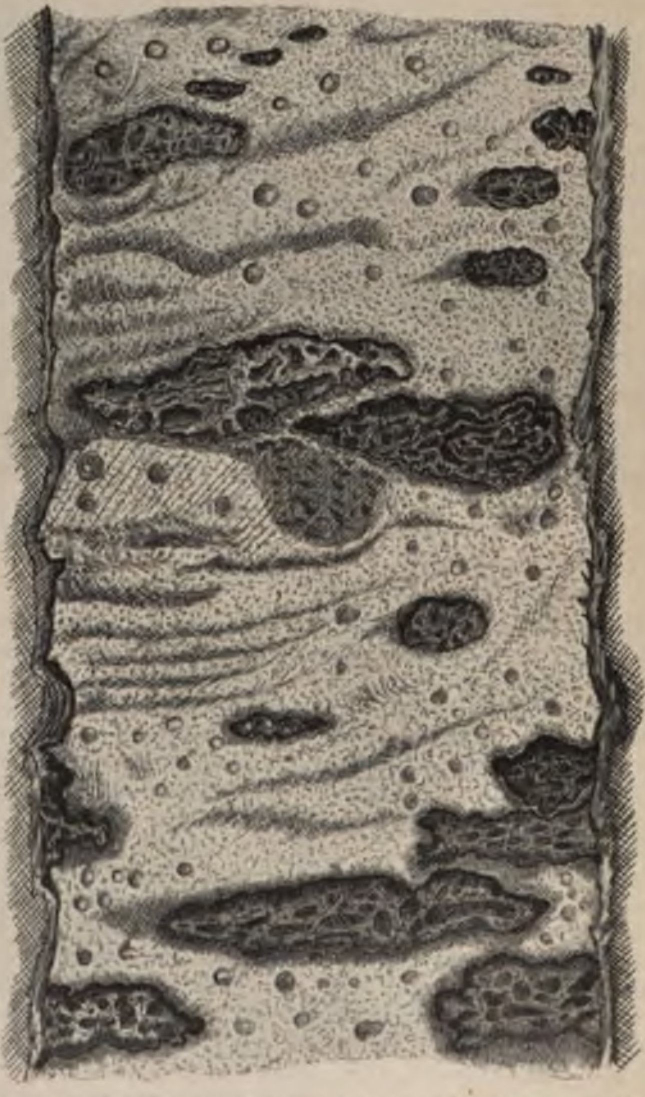


Fig. 405.—Tubercular Ulceration of Mucosa of Ileum. Between the Ulcers are seen the Tubercular Lymph-Follicles.

but less so than in the case of the typhoid. The infiltration of the edge is caused by tubercular deposit (Fig. 406, *a*). The ulcer, as a rule, is longer in one direction than in another, and the long axis usually lies transverse to that of the intestine (Fig. 405). There are exceptions to this general rule; the ulcer may be round instead of oblong. It very seldom perforates. There are probably two reasons for this: the one that the muscularis is rarely destroyed; the other that the serous

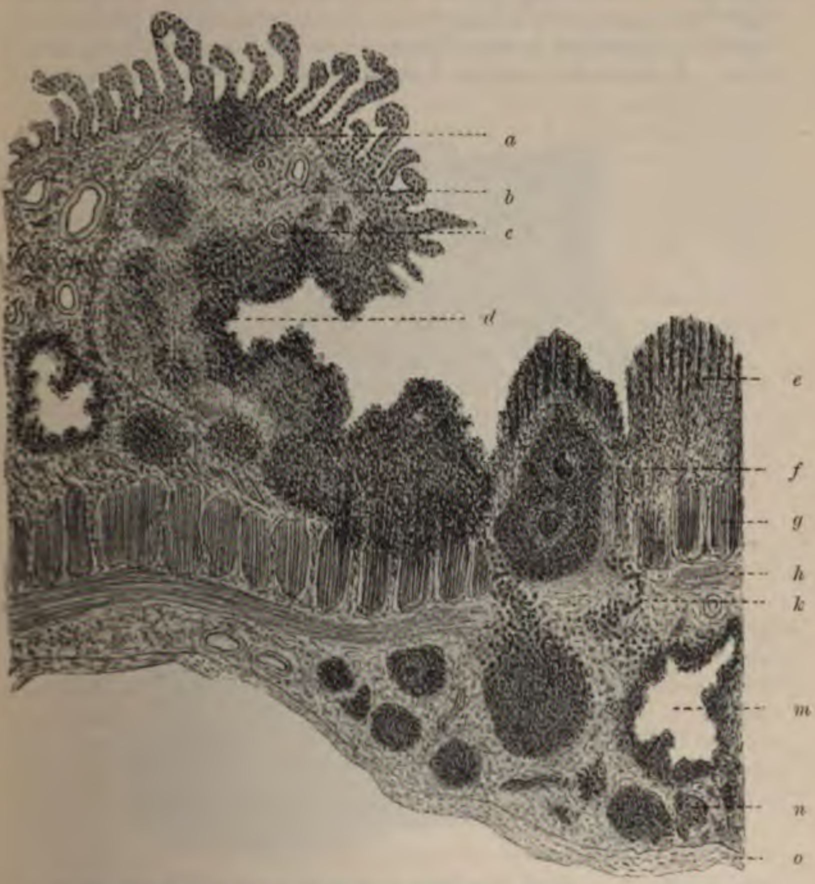


FIG. 406.—PERPENDICULAR SECTION THROUGH EDGE OF A TUBERCULAR ULCER OF INTESTINE (×50 DIAMS.)

(*a*) Tubercle in the infiltrated edge of the ulcer; (*b*) tubercular small cell infiltration of the edge; (*c*) a small artery; (*d*) the slight undermining of the caseous edge; (*e*) floor of the ulcer formed by the infiltrated submucosa; (*f*) tubercle on the floor with giant cells in it; (*g*) transverse muscular coat; (*h*) longitudinal muscular coat; (*k*) rows of cells passing through lymphatics from floor of ulcer out to the tubercular subserosa; (*m*) softened tubercle in subserosa; (*n*) another tubercle in same of younger date; (*o*) the serosa.

coat becomes thickened by deposit of cicatricial tissue opposite the ulcer. The serous coat is usually not much altered unless at points corresponding to the ulcers. Here, if the ulcer be of any standing, a cicatricial stellate milky patch will be found in which several gray tubercles are embedded (Fig. 407). The tubercles often radiate from a point in the serosa corresponding to the centre of the floor of the ulcer. A tubercular small-cell deposit (Fig. 406, *k*) can be traced running in lines through the muscularis out to the subserous coat, evidently along the track of lymph-paths. It implicates the lymphatic vessels of that structure, causes a thickening of them, and gives rise to the cicatrix-like appearance just referred to.

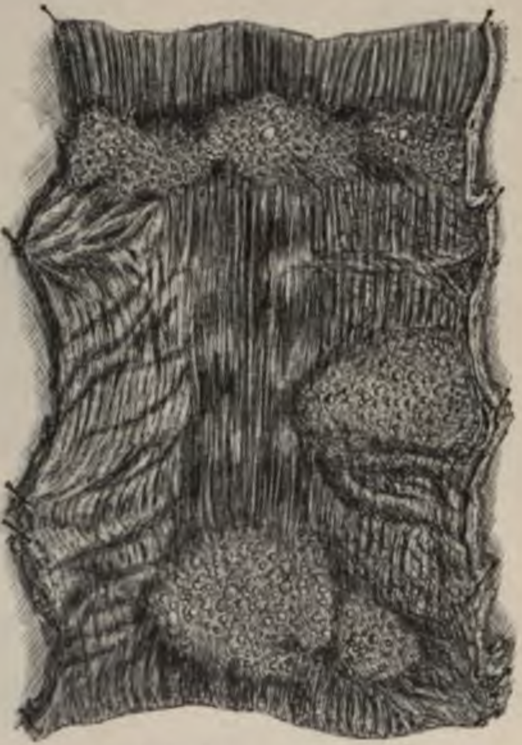


FIG. 407.—SEROUS COAT OF INTESTINE OPPOSITE TUBERCULAR ULCERS OF THE MUCOSA. CICATRIX-LIKE PATCHES WITH NUMEROUS TUBERCLES IN THEM ARE SEEN AT THE PARTS CORRESPONDING TO THE ULCERS.

The mucosa surrounding the ulcerated part may be congested, but the remainder of the intestine is not necessarily so.

The extent to which the destruction has spread is sometimes so great that there is hardly sufficient mucosa left to separate the one ulcer from the other. The condition of the intestine under such circumstances may come to resemble that of advanced tropical dysentery.

The disease evidently takes its origin in the lymph-follicles. These absorb and retain the tubercle poison, and within them a tubercular small-cell deposit with giant-cells soon makes its appearance. The deposits are rounded and circumscribed, and several may be found within a single nodule. The advent of caseation destroys the structure, and reduces it to an amorphous mass. When the dead materials are removed from the centre the tubercle goes on spreading at the edge; hence the hard and infiltrated character which the edge usually bears.

The mesenteric **lymph-glands** are always much enlarged and tubercular in regions corresponding to the site of the ulcers in the intestine.

The tubercles all along the alimentary canal tend to soften and to become excavated at an early period, probably owing to the intestinal juices acting upon their necrosed centres.

Lastly, it should be mentioned that the ulcer seldom heals completely; if a partial healing takes place at one point the infiltration tends to spread at another. A tight stricture of the bowel may be caused by a ring-like ulcer cicatrising.

INTESTINAL OBSTRUCTION.

Intussusception (*intus*, within, and *suscipere*, to receive).

863. This term is applied to a condition in which a contracted portion of bowel slips into a relaxed portion below. The intussusception probably never occurs in the opposite direction. The commonest seat of it, as might be expected, is the junction of small and large intestines. The narrow small intestine protrudes into the more capacious caput cæcum and colon. Some portion of the small intestine is the next common seat; it also occurs in the large intestine.

The cause of it is probably irregular contraction of the bowel. The function of the circular coat of muscular fibre is to contract and elongate the intestine, while the longitudinal coat widens and shortens it. Hence if the circular coat is thrown into action at one part, the bowel will become narrow and elongated and will tend to be pushed into the part below, more particularly if this be relaxed by the longitudinal layer of muscle being called into play.

When the invagination has once taken place, the upper segment of bowel tends to be pushed farther and farther inwards. The portion pushed inwards is known as the **volvulus** (Fig. 408, *d*, *d*), while an outer, a middle, and an inner layer are distinguished (Fig. 408, *a*, *b*, *c*). The outer layer is sometimes named the **sheath**.

The unnatural position of the bowel impedes the circulation within the volvulus, and in course of time extinguishes it. The latter consequently falls into a state of **gangrene,** separates from its attachments above, and is removed *per anum.* Several feet of bowel may thus become detached. The gangrenous separation, in most cases, is not complete before the eighth day. Death, however, usually takes place about the fifth day (Brinton), and hence in some instances a fair chance of the separation of the slough taking place is not afforded. Brinton estimates that the separation of the slough occurs in one in every two (or at most three) cases (No. 461, p. 47).

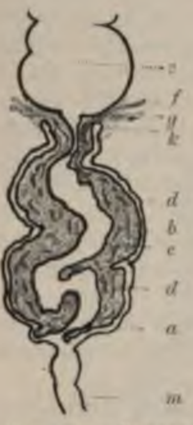


FIG. 408.—DIAGRAMMATIC SCHEME OF INVAGINATION OF THE BOWEL.

(*a*, *b*, *c*) Outer, middle, and inner layers; (*d*, *d*) volvulus with congested mesenteric vessels dragged into it; (*e*) distended portion of bowel above point of obstruction; (*f*, *g*) mesenteric artery and vein dragged into the invaginated part of the bowel; (*k*) effusion of lymph at point of invagination; (*m*) portion of bowel below point of obstruction.

Meanwhile, and previous to the volvulus separating, a localised inflammation of the adjacent serous surfaces has set in, whereby a fatal rupture of the bowel may be prevented. An annular effusion of lymph occurs at the point *k* (Fig. 408) which effectually glues the parts together, so that when the volvulus sloughs off the continuity of the bowel is still maintained.

Stercoraceous or fæcal vomiting is a symptom of intussusception and other forms of intestinal obstruction. As long as the volvulus remains attached little if any fæcal matter passes the point of obstruction. The old explanation of the fæcal matter finding its way upwards was based upon supposed reversed peristalsis. Brinton, however (No. 461, p. 7), showed that there is a double current as it were in the movement of the intestinal contents in such cases, an outer or descending, and an inner or central ascending. A double movement in fact results from the intestine contracting against the obstruction (see Fig. 409).

Post-mortem Invagination.

Invaginations of the small intestine are frequently seen after death in children, sometimes in adults. They take place probably as death approaches. They are known from the foregoing by the absence of inflammatory reaction and by their being multiple.

Other Forms of Intestinal Obstruction.

864. The intestine sometimes takes a **twist** (volvulus or ileus) which effectually obstructs its channel. The loop of bowel in such a case will be found loaded with diffluent fæcal matter, and often in a half-gangrenous condition.

Old fibrous bands, the result of a former peritonitis, sometimes induce a strangulation of a large mass of bowel. The bowel gets under the adhesion and becomes more and more firmly packed beneath it. The band is usually attached on the one hand to the mesentery, on the other to the abdominal wall. It sometimes consists of the omentum rolled up into a compact rope-like mass, at other times it is the terminal filament of a diverticulum ilei, in which case it is fixed to the umbilicus by its peripheral extremity. Obstruction may also be caused, of course, by various forms of **constriction**, such as that resulting from tropical dysentery, tuberculosis, or a cancerous ring. At other times **polypous tumours** may occasion it; they sometimes act in a valve-like manner, and effectually prevent the passage of fæcal matter.

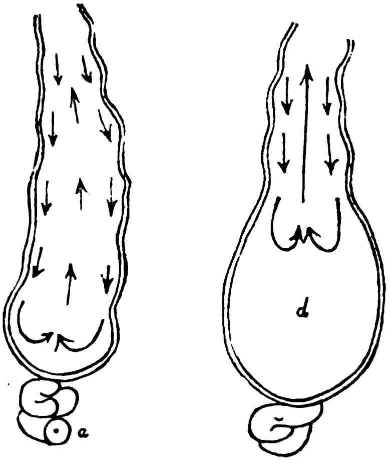


FIG. 409.—SCHEME OF INTESTINAL OBSTRUCTION TO ILLUSTRATE THE PERISTALSIS OF AN OBSTRUCTED BOWEL (AFTER BRINTON).

(*a*) Stage of moderate distension with forward and backward currents, as indicated by the arrows traversing the whole tube above the obstacle. The contracted segment of bowel below the obstacle is represented at lowest part of the figure. (*d*) Stage of extreme distension, in which the dilated and paralysed segment above the obstacle is scarcely engaged by either of these currents.

DIARRHŒA (διάῤῥοια, *a flowing through*).

865. The watery condition of the stools in diarrhœa seems to be due usually to one of two causes or to both, namely, failure in the intestinal contents to become consolidated as they enter the large intestine, and augmented watery efflux from the mucous membrane. In exceptional cases the quantity of mucus given off by the intestine may also be increased, thus adding to the liquidity of the dejecta. Exalted peristalsis accompanies the condition and causes an increased tendency to expulsion (Thiry).

The commonest proximate cause of diarrhœa in Man is the application of an irritant to the mucous membrane. This induces an efflux of liquid and excites peristaltic action. The irritant may be some poisonous matter contained in the food, or a pathogenic micro-organism.

The **summer diarrhœa of children** so common in this and other countries can be best accounted for on the latter grounds. It seems to follow regularly in the wake of a high summer temperature, and is commonest in damp low-lying districts. The dejecta in such cases sometimes swarm with zoogloea masses of what appears to be a *micrococcus.* The masses assume a spherical or polygonal form. Escherich has isolated a *comma-bacillus* from the dejecta, which possesses a spirillar shape like that of Asiatic Cholera.

Green Diarrhœa.—The dejecta sometimes assume a grass-green colour in the summer diarrhœa of infants. The colour appears to be caused by the green colouring matter thrown out by the *bacillus fluorescens non liquefaciens.* It is doubtful whether the organism can be regarded as the cause of the diarrhœa.

Tomkins (No. 6, 1889, ii. p. 180) states that the atmosphere of the town of Leicester at the time of an epidemic of summer diarrhœa contained at least double or treble the number of microbes or spores compared with periods before or after the epidemic. Further, that in the district of the town (low-lying and damp) most affected they were fourfold as numerous as in those districts of the borough where the disease did not prevail. He used Hesse's apparatus for examining the air.

The daily quantity of fæces in infants, according to Forster, Biedert, Wegscheider, and Uffelmann, should amount to about 40 grm. From 100 grm. nourishment 3 grm. fæces are given off. The normal colour is that of yolk of egg. Along with less solid constituents there are usually some so-called clots consisting of fat salts of lime and spores of fungi. Water is present to the extent of 84 to 86 per cent. Albumin can be detected only in small quantity and there may be traces of peptone. The fats are in the form of neutral fat, fatty acids, and soap, the latter from 10 to 20 per cent. Tests for sugar give negative results. The ash yields a large proportion of lime. Epithelium, mucus, bile-colouring matter, etc., are also present. The normal reaction in infants is somewhat acid, whereas in adults it is usually slightly alkaline, more rarely acid or neutral (Nothnagel). The acidity appears to be in main part caused by lactic acid.

SPRUE.

866. A peculiar form of intestinal disturbance is sometimes met with in tropical and subtropical climates, commonly known as "sprue." Thin (No. 193, xxxix. 1887, p. 337) proposes to call it "Psilosis" (ψιλός, bare) from the rawness or bareness of the mucous membrane of the tongue. It is often accompanied by diarrhœa, usually by an unnatural redness and sensitiveness of the tongue, and sometimes, although there is doubt on this matter, by albuminuria. The affection is also associated with great debility, probably in part from a considerable portion of the proteids passing through the intestine undigested, and is liable to become chronic. The state of the intestine has not been ascertained microscopically; but to the naked eye the mucosa is said to be thin and atrophied. It looks as if the epithelial surface had disappeared.

Literature on Intestinal Digestion.—**Bokai** (Movements of Intestine): Arch. f. exp. Path. u. Pharmakol., xxiv. 1887, p. 153. **Brunton and Cash** (Absorption of Gas by Intestine): St. Barth. Hosp. Rep., Lond., xxii. 1886, p. 289. **Cash** (Intestinal Rest and Movement): Proc. Roy. Soc. Lond., xli. 1886, p. 212. **Exner** (Peristaltic Movements): Arch. f. d. ges. Physiol., xxxiv. 1884, p. 310. **Hay** (Absorption of Salts from Alimentary Canal): Brit. Med. Journ., 1882, ii. p. 1204. **Heidenhain** (Small Intestine): Arch. f. d. ges. Physiol., xliii. 1888, p. 1, suppl.-hft. **Leubuscher:** Studien üb. Resorption seitens des Darmkanales, 1885. **Malfatti** (Use of Certain Alimentary Substances in Human Intestine): Sitzungsb. d. k. ad. d. Wissensch. Math.-naturw. Cl., 1884, Wien, xc. 1885, p. 323. **Röhmann** cretion and Absorption): Arch. f. d. ges. Physiol., xli. 1887, p. 411. **Rouch:**

Applications de la méthode graphique à quelques points de la physiologie du gros intestin, 1885. **Schäfer** (Origin of Proteids of Chyle and Absorption): Proc. Roy. Soc. Lond., xxxviii. 1884, p. 87; *also* (Absorption by Amoeboid Cells), Internat. Monatschr. f. Anat. u. Histol., ii. 1885, p. 6. **Spee** (Movements of Villi): Arch. f. Anat. u. Entwicklngsgesch., 1885, p. 159. **Voit** (Digestion of Cellulose): Sitzungsb. d. k.-bayer. Akad. d. Wissensch. zu München, 1869, p. 431. **Wenz** (Albuminous Bodies and Intestinal Digestion): Ztschr. f. Biol., iv. 1886, p. 1.

Literature on Micro-organisms of Alimentary Canal.—**Abelous**: Compt. rend. Acad. d. Sc., cviii. 1888, p. 310. **De Bary** (Micro-organisms in Stomach): Arch. f. exper. Path. u. Pharmakol., xx. 1885, p. 243. **Burkart** (Mycosis Intestinalis): Berl. klin. Wochnschr., x. 1873, p. 145. **Capitan and Morau**: Compt. rend. Soc. d. Biol., ix. 1889, p. 25. **David**: Les Microbes de la bouche, 1890. **Escherich** (Intestinal Bacteria of Infants): Fortschr. d. Med., iii. 1885, p. 515; *also*, München med. Wochnschr., xxxiii. 1886, p. 2; *also*, Arbeiten a. d. path. Institut zu München, 1886, p. 1. **Falk** (Relation of Infectious Substances in Alimentary Canal): Arch. f. path. Anat., xciii. 1883, p. 177. **Falkenheim** (Sarcina): Arch. f. exp. Path. u. Pharmakol., xix. 1885, p. 339. **Goodsir** (Sarcina): Collected Works. **M'Fadyean**: Journ. Anat. and Physiol., xxi. 1886-87, p. 227. **Miller**: Die Mikro-organismen d. Mundhöhle, 1889; *also*, American Transl., 1890. **Netter**: Progrès méd., v. 1887, p. 53. **Synopsis of Literature on**: see De Bary, Arch. f. exp. Path. u. Pharmakol., xx. 1886, p. 269. **Vignal** (Organisms of Fæcal Matter and Action on Alimentary Substances): Ann. de Physiol. norm. et path., x. 1887, p. 495; Comptes rend. Acad. d. Sc., cv. 1887, p. 311.

Literature on Diseases of Duodenum.—**Alloncle**: De l'ulcère perforant du duodenun, 1883. **Balfour** (Simple Ulcer): Edin. Med. Journ., xix. 1874, p. 933. **Bardeleben** (Simple Ulcer): Arch. f. path. Anat., v. 1852, p. 251. **Bucquoy** (Simple Ulcer): Arch. gén de méd., 1887, i. pp. 398, 526, 691. **Clark** (Simple Ulcer): Brit. Med. Journ., 1867, i. p. 661 *et seq.* **Collins** (Simple Ulcer): N. Y. Med. Rec., x. 1875, p. 677. **Curling** (Ulceration after Burn): Trans. Med.-Chir. Soc. Lond., xxv. 1842, p. 260. **Cuthbertson** (Ulceration after Burn): Med. Times and Gaz., 1867, ii. p. 347. **Dutcher**: Cincin. Lancet and Obs., ix. 1866, p. 664. **Eskridge** (Gangrenous Duodenitis): Tr. Path. Soc. Phila., ix. 1880, p. 18. **Fox** (Perforating Ulcer of Duodenum): Lancet, 1886, i. p. 250. **Gibbon** (Perforation after Scald): Trans. Path. Soc. Lond., vi. 1855, p. 189. **Hawkins** (Ulceration after Burn): Trans. Path. Soc. Lond., ii. 1849-50, p. 290. **Heckford** (Simple Ulcer): Lancet, 1866, ii. p. 577. **Hewett** (Ulcer after Burn): Trans. Path. Soc. Lond., i. 1848-50, p. 256. **Krauss**: Das perforirende Geschwür im Duodenum, 1865. **M'Carthy** (Ulcer after Burn): Trans. Path. Soc. Lond., xxv. 1874, p. 120. **Murchison** (Simple Ulcer): Trans. Path. Soc., ix. 1857, p. 917. **Nidergang**: Sur l'ulcère simple du duodénum, 1881. **Osler**: Duodenal Ulcer, 1887. **Robinson** (Simple Ulcer): Trans. Path. Soc. Lond., xix. 1868, p. 236. **Seigel**: Ueb. d. einfache chronische Duodenalgeschwür, 1877. **Stokes** (Ulcer after Burn): Dub. J. Med. Sc., lxii. 1876, p. 327. **Ulceration after Burn**: Med. Times and Gaz., vi. 1853, p. 554. **Wernich** (Rupture): Arch. f. path. Anat., l. 1870, p. 138. **Wilks** (Cases of Ulceration after Burn): Guy's Hosp. Rep., ii. 1856, p. 133.

Literature on Typhoid.—**Babes** (Bacillus): Centralbl. f. Bakteriol. u. Parasitenk, x. 1891, p. 281. **Brieger and Ehrlich**: Berl. klin. Wochnschr., xix. 1882, p. 661. **Cassedehat**: Ann. de l'Inst. Pasteur, iv. 1890, p. 625. **Chantemesse and Widal**: Ann. de l'Institut Pasteur, ii. 1888, p. 54. **Coats**: Brit. Med. Journ., 1882, i. p. 421. **Crooke**: Brit. Med. Journ., 1882, ii. p. 15. **Cygnaeus**: Beitr. z. path. Anat. u. z. allg. Path. (Ziegler), vii. 1890, p. 375. **Eberth**: Arch. f. path. Anat., lxxxi. 1880, p. 58; *Ibid.*, lxxxiii. 1881, p. 486. **Fraenkel and Simmonds**: Die aetiolog. Bedeut. d. typhus Bacillus, 1886. **Gaffky**: Mitth. a. d. Gesund.-amt, ii. 1884, p. 372; *also*, Eng. Transl. in "Bacteria in Relation to Disease," N. Syd. Soc., 1886. **Gasser** (Culture of Bac. in Coloured Media): Arch. de méd. expér. et d'Anat. path., ii. 1890, p. 750. **Uffelmann** (Bacillus): Berl. klin. Wochnschr., xxviii. 1891, p. 857.

Intestine—Obstruction.—**Fleiner**: Arch. f. path. Anat., ci. 1885, p. 484. **Goltdammer**: Berl. klin. Wochnschr., xxvi. 1889, p. 197. **Hamilton (G.)** (Two Cases): L'pool M.-Chir. Journ., viii. 1888, p. 247. **Kisch** (Reflex Causes): Berl. klin. Wochnschr., xxiv. 1887, p. 260. **Obalinski**: Berl. klin. Wochnschr., xxvi. 1889, p. 251.

CHAPTER LXXV

THE INTESTINE—(*Continued*)

Dysentery (δύς, *with difficulty*, and ἔντερον, *the bowel*).

867. **Anatomical Changes.**—The disease usually commences in the large intestine and may be entirely confined to it. Sometimes, however, the small intestine becomes secondarily affected. It is in these cases that the earlier stages of the lesion can be studied.

An injection of the blood-vessels of the serosa commencing in the jejunum, and often spreading itself over the entire small intestine, is a constant feature. The mucosa has a dark red or purple colour from like deep injection of its vessels. Then follows a thickening of the mucosa and submucosa from inflammatory effusion into them. The valvulæ conniventes lose their membranous character and become converted into thick annular protuberances. The surroundings of the Peyer's patches are much congested, and hence map these bodies out with unusual distinctness. The patches themselves, however, are free from infiltration, a fact which might serve to distinguish a doubtful case from typhoid.

Towards the lower end of the small intestine the mucosa has a rusty brown colour, and has become so detached from underlying parts that it can easily be scraped off with a knife. The detachment and disintegration, however, are seldom uniformly distributed.

Coming down to the large intestine, it will be found that, in addition to the thickening and congestion, large portions of mucous membrane have sloughed off, while shreds of the same are found lying loose or dangling by slender isthmus-like pedicles. The separation seems to take place at the submucosa. It is here that the infiltration is greatest, and it is here also that the disintegrative necrosis is most active. The floor of the denuded parts of the intestine is constituted by the muscularis, which seldom seems to be destroyed to any extent. Hence perforation is usually prevented.

When the mucosa has got into this tattered condition it never seems to recover itself. Even after years the tags of membrane which have preserved their vitality will be found floating free in the channel of the bowel. Unfortunately, however, the bowel has a tendency to cicatrise circumferentially, and this brings about a stricture of its lumen.

The disease is often associated with abscess of the liver (Sect. 685).

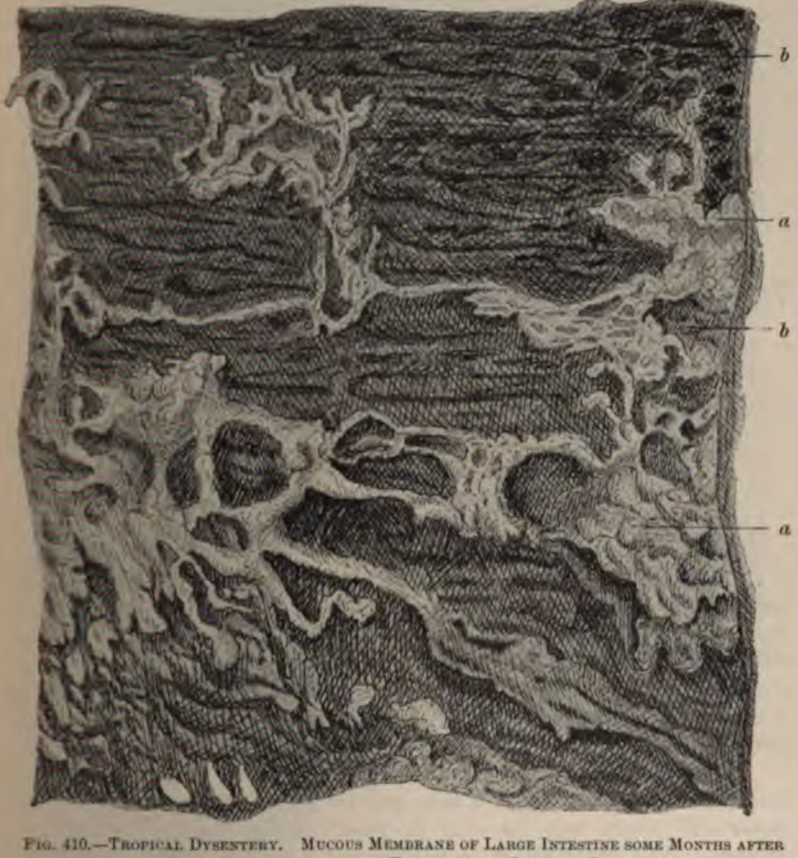


FIG. 410.—TROPICAL DYSENTERY. MUCOUS MEMBRANE OF LARGE INTESTINE SOME MONTHS AFTER AN ACUTE ATTACK, SHOWING ITS TATTERED AND SHREDDY CONDITION.

The tags of tissue (*a*, *a*) represented are all that remains of the mucosa. The intervening parts (*b*, *b*) correspond to the muscularis.

Etiology.—The whole character of the disease points to its being of parasitical origin. Yet although the surface of the sloughy bowel may be covered with masses of micro-organisms, a distinct and indubitable dysenteric organism has not as yet been isolated.

A curious association with the disease is that of the **amœba coli** (Fig. 411) described by Lösch (No. 13, lxv. 1875, p. 196), Kartulis

(No. 13, cv. 1886, p. 521), and others. It occurs in the contents of the large intestine, and sometimes abundantly in the dejecta. It is usually enveloped or entangled in a mass of mucus. Whether it has anything to do with the causation of the malady, or whether its presence is to be regarded simply as an epiphenomenon, remains undecided.

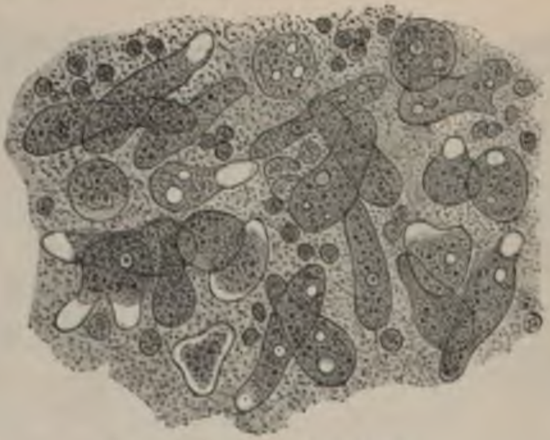


FIG. 411.—AMŒBA COLI IN DYSENTERY.

CROUPOUS ENTERITIS.

868. *Syn.*—English Dysentery, Cholera Nostras.

The mucous membrane of the bowel, like most other mucous membranes, is said to be subject to a croupous inflammation—that is to say, an inflammatory engorgement in which a croupous exudate is poured out on the surface, and from which fibrinous lymph is precipitated in the shape of a false membrane. The large intestine is the part of the bowel which is usually said to be affected with this alleged disease.

The mucosa is deeply injected and has a dark red colour, while the surface is covered with a thin pellicle of a grayish colour. Small superficial ulcers may be seen in great abundance on the injected mucosa. The condition is associated with severe diarrhœa, and the disease is sometimes known clinically as "English dysentery." It frequently proves fatal.

The microscopic examination reveals appearances somewhat different from what might be expected. There is little if any fibrin on the surface, and the gray, somewhat pultaceous, deposit which can be scraped off, and which destroys the natural moist lustre and smoothness of the mucosa, is in reality *a superficial slough* of the mucosa itself (see Fig. 412, *a, a, a*). There may be cases in which a distinct fibrinous membrane can be detached, but these certainly do not constitute the general run of fatal instances of so-called croupous enteritis. The mucosa and contained crypts seem to lose their vitality, become fatty, and are cast off.

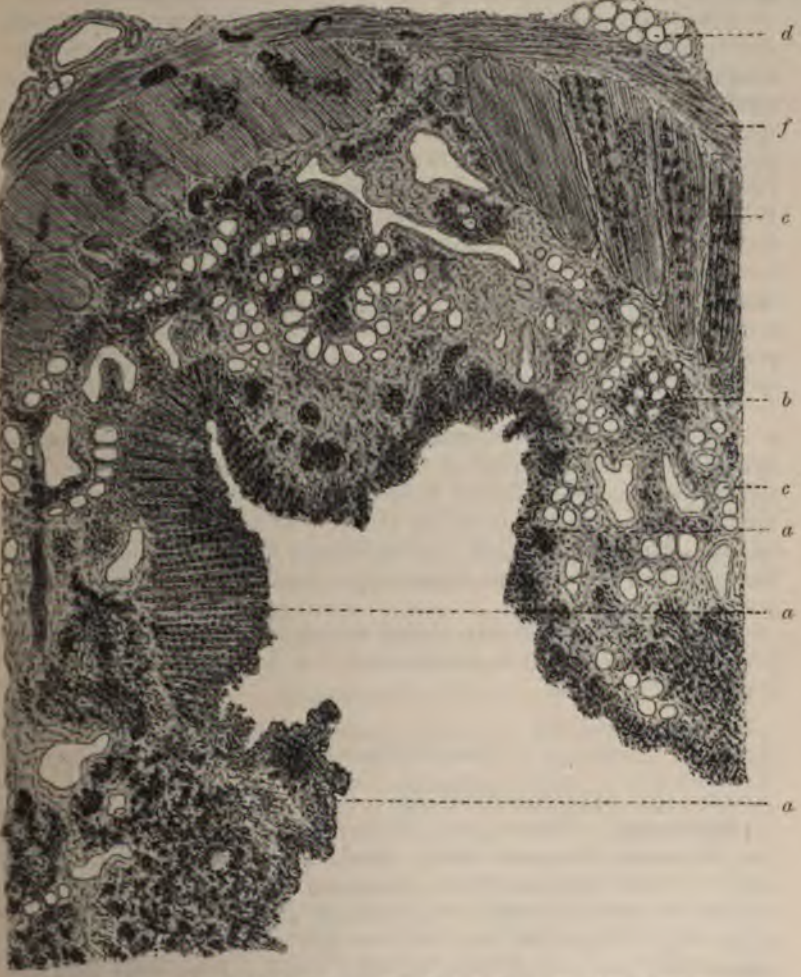


FIG. 412.—SECTION OF LARGE INTESTINE IN CROUPOUS ENTERITIS (×50 DIAMS.)

(*a*, *a*, *a*) The ulcerated mucosa with dead tissue on its surface—the so-called false membrane; (*b*) deposits of small round cells with hæmorrhages in submucosa; (*c*) fat cells in submucosa; (*d*) fat cells in serosa; (*e*) transverse muscular coat with localised hæmorrhages into it; (*f*) longitudinal muscular coat with congested vessels (Logwood, Fuchsin, and Clarified).

The vessels of the intestine out to the subperitoneal fat are much dilated and engorged with blood. Those of the peritoneum appear to escape. Numerous large extravasations of blood are seen in the mucosa, in the submucosa, and spreading between the bundles of fibres of the muscularis. The half-detached portions of mucous membrane are filled with blood effused from the over-weighted vessels. Aggregations of leucocytes are present in the vessels as well as outside of them.

Masses of granular matter are found on the surface of the sloughs and in their substance, but the author has as yet failed to detect any unusual accumulation of bacteria by the use of Gram's or other methods of procedure. By Gram's method, however, numerous disc-shaped bodies like immature coloured corpuscles are revealed in abundance. So numerous are they in some vessels as to constitute thrombus-like masses. They lie side by side with ordinary coloured corpuscles which are somewhat larger than the bodies in question. Their interior is occasionally slightly granular, and they appear in most instances to have become contorted. So intensely do they colour with fuchsin or gentian-violet that the result might almost be regarded as a reaction. When every trace of colour has been washed out of the preparation they are seen brilliantly stained. Similar corpuscles are occasionally found in tubercular lungs.

Termination.—Croupous enteritis appears to end sometimes in a cicatrisation of the wounded parts not unlike that of tropical dysentery. The remainder of the coat of the large intestine is thick and fibrous and the channel becomes constricted. The scars from the ulcers are so numerous on the surface that little of the mucosa may be left. Villous or polypoid projections may be seen on the mucosa of the lower end of the ileum, apparently a result of the previous unduly great vascularity.

The relationship of this disease to tropical dysentery has not as yet been made out. It is possible that it is closer than in this country is generally supposed.

ASIATIC CHOLERA.

869. *Syn.*—Epidemic Cholera.

Historical.—Cholera, with the exception of influenza and small-pox, is perhaps the most widely disseminated contagious malady we know of. Curiously, however, it has not been always so. There is evidence to prove, no doubt, that in India and possibly also in China it has been indigenous from the remotest times. Ancient Sanscrit manuscripts give a description of what could not be other than this we now recognise as Asiatic cholera; while contemporaries in China of Hippocrates and Confucius have under the name of Ho-luan recorded a disease which is generally considered to be identical with the cholera of modern times. It was not, however, until the present century that it began to take on a tendency to travel. Previously it remained indigenous in the countries where it was engendered, and chiefly in India. In the beginning of this century, probably with the advent of increased commercial facilities, it began to spread periodically into foreign lands, and to overrun ultimately the whole of Europe and a great part of America. It is questioned whether before this time the disease was even known in Europe, the descriptions given by Hippocrates, Galen, Celsus, and others appearing to refer to what we now designate as *cholera nostras*, not to true Asiatic cholera. There is one significant point about true cholera, namely, that wherever it occurs and whatever people it affects it induces the same line of symptoms, and is accompanied by the same fatal consequences. Hence had there been any great prevalence of the disease in Europe in bygone times we would certainly have had some record of it handed down to us. Nothing of the kind, however, is to be met with, until the year 1817, the memorable year in which the disease became pandemic.

The Source of the Disease.

India undoubtedly is the great nursery of the disease. Several districts have now become notorious, so much so that they can hardly be said ever to be entirely free from it; but of all localities, that of the **Delta of the Ganges** stands pre-eminent in this respect. The Ganges towards its divulgence into the Bay of Bengal unites with the Brahmaputra, and the waters from the two sources open by a series of seventeen main arms into the sea. The district around these is known as the Sunderbunds, and perhaps is the most unhealthy for human beings of any locality on the face of the globe. Vegetation is rife, the brackish tidal waters continually soak the decaying vegetable matter, and the temperature is such as to encourage those conditions which we know to be most favourable for the growth of most vegetable parasites. It is here that apparently the cholera parasite is fostered and grows. The district is almost uninhabitable on account of its attacks and those of malarious diseases, and the few natives who are to be found in the district do their best to propagate the disease by floating their dead on rafts away, as they hold, to the celestial fields.

Direction followed by it.

From this hotbed of cholera the contagion has spread westwards, broadly speaking, in three directions. The first and earliest was along the valley of the Ganges to the north-west provinces of India into Afghanistan, thence, by caravan routes, by way of Balkh, Bokhara, and Khiva to Russia. The second followed the course of the Gulf of Persia south-west to Syria and Egypt, and north-west towards the Caspian Sea. The town of Astrakhan, on the west shore of the Caspian Sea, has always been a stronghold of the disease through whatever route Russia has been invaded, and lying as it does at the mouth of the Volga, the disease has invariably run a rapid course upwards to Saratov and Kasan. The third route is that which cholera has always followed since the pandemic of 1865 with the exception of the outbreak of 1892. The Red Sea littoral has been the great starting point, the disease being brought thither by pilgrims to the Holy City. Thence it has spread rapidly into Egypt and along the Mediterranean. The pandemic of 1892, curiously and as presently to be explained, reverted to the old route through Afghanistan from Northern India.

THE FIRST FOUR GREAT PANDEMICS.

Previous to the year 1875 there had been four great pandemics of the disease, all starting from Indian soil. The first occurred between the years 1817-1823, the second between 1826-1837, the third from 1846-1863, and the fourth between 1865-1875.

The exact origin of **the first** of these is somewhat obscure. In May of 1817 it was at Kishnaghur, on the Hooghly, in the beginning of August at Calcutta, and in the middle of the same month at Jessore. Indeed, the last-mentioned town, situated a short way from Calcutta, generally gets the credit of having been its starting point. In four months it had broken out in the greater part of lower Bengal. Early in November it was rampant at Mirzapore and in the Bundelkund State, where it proved most disastrous to the army under the command of the Marquis of Hastings, then Governor-General of India. The detachment consisted of 10,000 combatants and 80,000 servants and followers. The disease insinuated itself insidiously among the followers on the 7th and 8th November 1817, and in a few days spread through the whole camp. Young and old, European and native, were equally struck down by it. The sentinels dropped at their posts as if they had been shot, so that three or four men were required for a watch extending over a couple of hours. Many of those who were seized died before reaching the camp hospitals, and men conveying the sick were often seized on the way and died. Ultimately the living proved quite incompetent to bury the dead, and what remained of the troops were saved only by shifting camp to hilly ground in the neighbourhood. A number, amounting to 7064 combatants and 8000 followers, died in this single outbreak.

During December and February the plague seems to have become latent or actually extinguished for the time being, but in March 1818 it reappeared in most of the places formerly visited by it. It now spread over nearly the whole of Hindostan; only a few districts escaped, more especially those which were hilly. It ran up the valley of the Ganges, in a north-westerly direction, through Agra, Mattra, Delhi, Oudh, and Lucknow, to the Punjaub, while offshoots struck southwards and westwards. So that in August it reached Bombay, and subsequently overran the Konkan and Malabar coast to reach the southernmost limit of Hindostan towards the end of 1818 and the beginning of 1819. As early as 1818 it had already crossed its indigenous borders, having invaded Ceylon, and in time completely overspread the whole island. It also found its way over Burmah and Siam to Singapore, and in the year 1820 to Java, Borneo, and other of the Sunda Islands. China lastly fell a victim to its ravages, and proved a congenial soil on which to flourish. It spread devastation from one end of the country to the other. It travelled westwards, somewhat later than east and southwards. It showed first at Muscat on the east coast of Arabia, whither it had been transported from Bombay. It crossed to the coast of Persia and travelled north towards the Euphrates and interior of Persia. It penetrated finally in the spring of 1823 to Syria and Palestine, and in May of that year reached Russia. Curiously it began to die out in October, and was extinguished in all the places visited in the following winter. Thus ended the first pandemic outbreak of cholera on extra-Indian soil.

The commencement of **the second** pandemic dates from the year 1826. It bebecame prevalent in Bengal and passed up the valley of the Ganges. Its westward course was effected by two routes. One of these was from Lahore in 1827 to Cabul, Balkh, and Bokhara by caravan routes. In 1828 this branch had reached Khiva, and in 1829 Orenburg in Russia. The disease, however, as propagated along this line died out in the following winter. The second route which it took lay through Persia in 1829 to Teheran in the autumn, and finally to Astrakhan on the west coast of the Caspian Sea. From this last focus, as always happens, it spread up the Volga to Saratov and Kasan. Before 1830 it had taken a firm hold upon Russian soil, so firm that even the cold winter of 1830-1831 did not stop it. In the early months of 1831 it had reached the Baltic provinces and Poland. The Russo-Polish war, which was raging at the time, served to diffuse it wide-cast. In June St. Petersburg was stricken, and in July it penetrated as far northward as Finland. It was conveyed also to Arabia by pilgrims, whence it spread, through their intermediation, over Egypt, Syria, and Palestine. It ran up the Nile as far as Thebes and down to Alexandria. It reached Germany by three routes, the first directly from Poland, the second through Danzic by Russian ships of war, and the third also from Russia, but by way of Austria.

From Germany it was conveyed to Great Britain in 1831. A vessel from Hamburg brought the disease to Sunderland in October of that year, and outbreaks speedily occurred in Newcastle and Gateshead. By December it had reached Scotland, and in the course of a year, following commercial highways and rivers, had overspread the greater part of Britain. Hilly districts were usually exempt, our Scotch Highlands having remained quite free from it. France was smitten about the same time as this country, and from France the disease found its way into Belgium. Denmark escaped completely, but Norway and Sweden suffered severely in the year 1834. Before it had reached the south-west of Europe it had already crossed to America. Canada was attacked in the beginning of June 1832; it spread with terrible rapidity along the St. Lawrence and its tributaries. The States were also severe sufferers, the disease penetrating to the Pacific across the Rocky Mountains. South America was invaded in 1835, where the disease committed great ravages. The pandemic continued to press into Southern Europe. Spain and Portugal fell ready victims to it in the year 1833, Marseilles in 1834, Piedmont in 1835. Thence it was carried into Southern Italy, Austria, Sicily, and Malta. This second pandemic died out in the year 1837-1838 at every point throughout the vast territory over which it had spread.

The third great pandemic, that of 1846-1863, followed much the same route, arising in India, spreading gradually over Persia, Russia, and Europe, and finally crossing to America.

The fourth, that of 1865-1875, was much more rapid in its progress, owing no doubt to the increased facilities for commercial intercourse. Like most of the later cholera waves, it did not follow the old overland route through Persia by the slow instrumentality of pedestrian and equestrian transport, but was brought to the coast of Arabia directly by pilgrims. Thence it spread in a few weeks over a large part of southern Europe. As usual it took origin in the lower basin of the Ganges. In all these visitations Australia remained practically exempt, and the islands of the Pacific, the Cape of Good Hope, and the central parts of Africa enjoyed a like immunity.

THE EPIDEMIC OF 1892.

The danger of a rapid spread of the malady is nowadays, of course, far greater than formerly. What was formerly a matter of years has now become one of weeks or days owing to steam traffic. **Mecca** seems to be the great centre of the evil. Thither, pilgrims, gathered from all parts of the East, convey periodically the germs of the disease and disseminate them broadcast. The Holy Well of Mecca appears to be a veritable cholera laboratory. The water is contaminated beyond description with all manner of abominable impurity. A bucket of this is emptied over the head of each of the faithful, the excess being allowed to run back into the source from which it was obtained. A quantity of the water is also drunk by each pilgrim. At the last ceremony which took place, the twelve miles of road to Ararat were in a few days thickly strewn with the dead, some 30,000 having ultimately succumbed. This epidemic appears to have come from India along the old route by the northern provinces, Afghanistan, and Russia in Asia. It showed violently in Srinagar, in Cashmir, in May of the same year. It was reported in Askabad on 4th June, having meanwhile traversed Afghanistan. From this point it spread rapidly westwards by the Trans-Caspian Railway, the great highway of commerce of the district. It struck two points on the western shore of the Caspian—namely, Baku and Astrakhan. From Baku it was carried by the Trans-Caucasian Railway to Tiflis, where it arrived on 26th June, and from Astrakhan it again ran up the Volga by the steamboat traffic to Kasan. Moscow was reached on 5th August, and St. Petersburg on 17th August. It was next conveyed by the stream of Russian emigrants to Hamburg and Antwerp, in the former of which cities it committed tremendous ravages. Thus in from three to three and a half months it found its way from Northern India practically to our own doors, a distance which in former times was traversed in about as many years.

THE CHOLERA GERM.

It is now pretty well accepted on all hands that the vegetable parasite—the cholera bacillus, spirillum, or spirochæta—discovered by Koch is the active agent, the materies morbi, of Asiatic cholera.

The history of the discovery of this parasite is as follows:—In the year 1883 a Commission, equipped by the German Government, investigated the cause of the disease in the Greek Hospital at Alexandria. The results so far were in great part negative. They satisfied themselves, however, that the blood was free from organismal impurity; that there were only a few organisms in matters vomited, but that they were very abundant in the dejecta. All the organs were remarkably free from organismal impurity. At this time Koch had not discovered the preponderance of a particular organism in any of the excreta. Inoculation and feeding experiments with mice and rats proved quite negative; the animals remained after such experiments in remarkably good health.

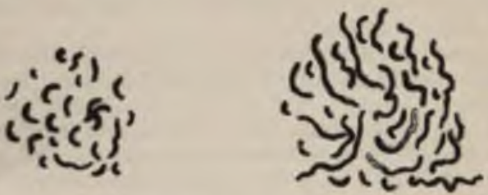


FIG. 412.—KOCH'S CHOLERA SPIRILLUM SHOWING COMMA AND SPIRILLAR FORMS ($\frac{1}{12}$ HOMOG. IMM SWIFT), STAINED WITH FUCHSIN.

In the year 1884 another German Commission, Koch being at the head of it, was sent out to India, with the result that the preponderance of a comma-shaped organism in the intestinal walls and dejecta was satisfactorily made out.

Morphology and Conditions of Growth.—The organism in question is about from a half to two-thirds the length of a tubercle bacillus, but much more bulky, and thicker than the latter. Sometimes the individuals hang in couples, or the curve may be double, resembling the letter S (Fig. 413). Like the spiralla of Finkler-

Prior and of Deneke, it is a ciliated organism. When stained by Van Ermengem's method (No. 609) the cilia are seen to be long and often very tortuous (see Fig. 414).

When cultivated artificially, the curves of the organism become more numerous, so that a spirillar or cork-screw-like body results (Fig. 413). This is now regarded as a degenerative form; it is found only in old exhausted cultivations, not in the alimentary canal or dejecta.

Spore-like bodies have been described within the little curved rod. These, however, are held to be mere vacuole cavities, such as are seen in the typhoid organism and in some others. Hueppe, Babes, and Neisser have alleged that the organism also divides in a chain-like fashion, and that *arthrospores* develop among the individuals of the chain. Such allegations, however, are as yet of somewhat doubtful value, the general impression being that the organism under ordinary circumstances does not spore. This is a matter of the greatest importance; for, as we know from the study of other like parasites, the spore is much more resistant to destructive agencies than the bacillus, and when dried may be kept almost indefinitely, ready to bud forth again when placed upon a congenial soil. Not so the bacilli. These are readily destroyed by drying, slight excess of heat, etc. The cholera organism, indeed, seems to be more easily killed than most other microbes of the same type. Thus the bacillus of anthrax may be dried, say, on a cover-slip, and will still retain its vitality for several days; some others retain theirs for weeks even although perfectly spore-free. The cholera organism, on the contrary, dies at latest in three hours after being air-dried in a thin film.

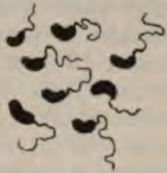


FIG. 414.—CHOLERA SPIRILLA FROM A CULTURE STAINED BY VAN ERMENGEM'S METHOD AND SHOWING THE CILIA.

There seems therefore little chance of the disease being transmitted by it on the surface of packages, etc., coming from a cholera district. There is no history of even an isolated case having arisen through such a means of contamination.

In the moist condition, however, its vitality may be retained for months or years if the supply of atmospheric oxygen be plentiful.

In most of, but not in all, the great epidemics of cholera the disease has died out or become latent with the advent of winter. The reason of this is apparently that the cholera microbe will not grow below 16° C. Its development is somewhat lively at from 17° to 18° C.; the temperature which is most favourable is from 30° to 40° C. When heated up to 60° C., its vitality is entirely destroyed in ten minutes, indeed, probably long before this; a very low temperature, however, although it inhibits the growth of the microbe, does not kill it. As soon as the suitable temperature and other necessary conditions are forthcoming, its vitality breaks out afresh with unabated vigour.

LANE LIBRARY

It will not grow on an acid basis, and any excess of acid, organic or inorganic, is fatal to it. Hence, although it may adhere to the outside of acid fruits and vegetables, the contagion is probably not conveyed to any great extent by means of these. It flourishes readily upon **fresh milk**, but whenever the milk becomes sour the organism perishes. There are many vegetable substances, however, upon which the poison may be for long retained unimpaired if in a moist state, and there are some on which it actually flourishes. It fails to propagate itself in an atmosphere of carbonic acid, but this gas does not destroy it.

Poison secreted by it.—As before mentioned, it is not found in any part of the body unless the wall of the alimentary canal, sometimes, in the most severe cases, not even here, but only in the contents. The cramps, depression of the heart, and other phenomena so characteristic of the malady cannot therefore be explained by the presence of the organism itself, but must be caused by the deleterious influence of a poison secreted by it. Old cultures of the cholera spirillum in gelatine and on other bases contain a poison which induces in animals paralysis of the extremities and heart, with cramps of various muscles throughout the body, such as those of respiration, the pupillary muscles, and those of the extremities. It is possible also, as suggested by Wood, that when the microbe is grown with insufficient oxygen, as under natural circumstances, this poison is secreted in greater quantity that when oxygen is freely supplied to it.

Early Recognition of the Organism.

To discriminate between this spirillum and others which are found in the human body, some of them in the same site as that under consideration, is not always an easy matter. Among those most likely to be mistaken for the organism of true Asiatic cholera, a spirillum discovered by Miller and Lewis in the mouth of healthy persons, that isolated by Finkler and Prior from the dejecta of ordinary cholera nostras, a spirillum discovered by Deneke in old cheese, Weibel's spirillum inhabiting the nasal mucous membrane, Escherich's comma and spirillar forms found in the dejecta of infants suffering from summer diarrhœa, Van Ermengem's comma and spirillar organisms found in the intestine of the guinea-pig, and the spirillum isolated by Gamaléja from the intestine of the fowl in a form of dysentery from which fowls suffer in Odessa—known as Metchnikoff's spirillum—may be mentioned. Any one of these is likely to be confounded with the spirillum of Asiatic cholera unless due precautions are observed. The three which most resemble each other in their morphology and manner of growth are—(1) The spirillum of Asiatic cholera; (2) that of Finkler-Prior; and (3) that of Deneke. Metchnikoff's spirillum has also a certain resemblance, but can be distinguished readily by its manner of growth. One of the chief diagnostic points lies in the appearance of cultures upon gelatine medium.

The two organisms between which it is generally necessary to distinguish in a suspected case of Cholera Asiatica are Koch's comma bacillus and the Finkler-Prior organism found in the dejecta of so-called cholera nostras. With a little experience there is not much difficulty in diagnosing them :—

Thus, when sown at a summer temperature on a gelatine plate it will be found that the colonies of the Finkler-Prior are larger than those of true cholera, their border is more regularly rounded, and they have a yellowish-brown colour. Both liquefy gelatine, but one of the most characteristic differential features is *the period at which the liquefaction of the gelatine takes place.* By the end of forty-eight hours liquefaction is advanced in the case of the Finkler-Prior ; whereas in the case of Koch's organism it may be hardly perceptible on the third or fourth day.

In a puncture culture the appearances at first are very much alike (see Figs. 492, 493). In both, the growth develops a bell-like area of liquefaction at its upper extremity. Soon, however, this bell-like appearance of the liquefied part stretches outwards much more rapidly in the case of the Finkler-Prior than in that of Koch's organism. By the third or fourth day, accordingly, while the bell-like appearance in the case of cholera may be still recognisable, in that of the Finkler-Prior the liquefaction has extended outwards and along the line of the inoculating needle to such an extent that it gives rise to a funnel-like space in the centre of the gelatine, filled with the liquefied medium. A little vacuole is often seen at the upper limit of the tract in the case of the cholera organism. It looks like a gas-globule. Too much reliance should not be placed on this as a point of differentiation.

Microscopically, it is difficult or practically impossible to distinguish the one from the other.

Deneke's organism also liquefies the gelatine much more rapidly than Koch's.

Additional Points of Diagnosis.—There are several other confirmatory diagnostic features :—(1) Thus, when the organism of Asiatic cholera is grown on potato at a temperature of 24° C. it throws out a brown pigment very much like that of the bacillus of glanders. The Finkler-Prior organism, on the other hand, becomes only slightly grayish-yellow on the surface. (2) The cholera organism grows on fresh sterilised milk readily and without curdling it ; whereas the Finkler-Prior and Deneke parasites first curdle it and subsequently peptonise it. Deneke's, further, throws out a yellowish pigment on the surface which the others never show. (3) As discovered simultaneously by Poehl, Bugwid, Dunham, and Brieger, old liquefied peptone gelatine cultures of the cholera spirillum give a pink to a red colour on addition to the liquid of a mineral acid. Many other liquefied gelatine cultures give the same, but in the case of the cholera organism it appears more rapidly and is more evident than in any of the others. This test is much relied upon by Koch (No. 366, xiv. 1893, p. 159). It is not conclusive, but is a useful adjunct to the test repertory; it is an indol reaction. (4) Another test said to be of great value was devised by Cahen. A flask containing sterilised bouillon coloured with litmus is inoculated with Koch's spirillum and retained at a temperature of 37° C. In twenty-four hours the litmus, by reduction, becomes decolorised. The Finkler-Prior and Deneke organisms decolorise at a temperature of 27° C. (5) The cholera organism does not induce putrefaction. The odour given off from a culture of it is peculiar and in a manner characteristic.

Question of Koch's Organism being the Specific Agent.—With these various measures to hand, there is not found to be much practical difficulty in distinguishing Koch's organism from all others. It should be remembered, however, that occasionally the difficulty is supreme, and that the most practised bacteriologists have been deceived. No one test should ever be relied upon. That being so, there comes the question of whether it is the actual cause of Asiatic cholera. And, as yet, the evidence on the subject may be said to be somewhat faulty from the fact that there is no animal which will take human cholera. Had it been otherwise, it is likely that the fauna of the Sunderbunds would have become extinct long ere this. All attempts to inoculate animals up till recently might have been reckoned as almost complete failures. Of late Gamaléja, after intensifying the poison by passing it through the systems of different genera of animals, vouches to having succeeded in growing Koch's comma bacillus upon the blood of the pigeon, guinea-pig, and dog.

But with it all one may well pause before concluding that true Asiatic cholera, alike with the disease in Man, has been thus or by any other expedient artificially conveyed to any of the brute creation. There seems to be something very peculiar about the conditions under which it will take hold upon even the human frame. Artificial growths have been swallowed by Klein and others, and minute portions of the actual dejecta, made into pills, by Bochefontaine, without any harmful result. Nay, Ferran's preventative remedy for the disease consisted in injecting a pure culture of the organism subcutaneously into the cellular tissue and muscles of healthy individuals likely to fall victims to it. There appears to be only one case on record where it seems to have been contracted from an artificial culture—in a medical man attending Koch's cholera course in Berlin. From the fact, however, that Koch's organism is found in cholera alone, and seeing that it appears when Asiatic cholera appears, increases with its progress and severity, and vanishes as recovery sets in, most authorities both in this country and abroad have come irresistibly to the conclusion that in this microbe discovered by Koch we have the true source of the evil.

State of the Intestine and Dejecta.

There is usually more or less congestion of the mucous membrane of the small intestine. It has a rosy red colour and the lymph-follicles may be enlarged and project from the surface. The rice water stools contain a little epithelium, but only exceptionally. The flaky precipitate is caused chiefly by mucus (Kühne, Bruberger, Hirschberg, Cohnheim —see No. 31, ii. p. 127). The epithelium, however, desquamates copiously after death, as a result of maceration. Within the flakes of mucus are numbers of colourless cells and multitudes of bacteria, the comma bacillus being in abundance. The vomit is said to present the same character as the dejecta, only it is thinner from admixture of water taken into the stomach. The specific gravity of the rice water stools comes up to 1006-1013. The reaction both of the vomit and alvine evacuations is neutral or alkaline. The inorganic constituents are more abundant than the organic and there is a preponderance of sodic chloride. Urea is constantly present or its derivative ammonium carbonate; while albumin is found only in proportion so small that boiling and nitric acid occasion a mere opalescence. Kühne described a saccharifying ferment in the dejecta (Cohnheim, No. 31, ii. p. 124).

Means by which the Disease is spread.

How does the organism invade the human body? On this subject we have acquired much insight of late; and of all the means by which contagion is effected, apparently the use of contaminated drinking water is the one which is most to be dreaded. The superstition and mystery associated popularly in former times with its manner of propagation have now been abandoned. Cholera is essentially a dirt disease, and if we keep ourselves clean—in the sanitary sense—the likelihood of catching cholera is of the slightest. As Hart remarks (No. 6, 1892, ii. p. 562):—We may lay aside all pedantry and mystery—we may talk, if we choose, of "epidemic constitution," "pandemic waves," "telluric influences," "cholera blasts," "blue mists," and the like terms of art with which an amiable class of meteorologists has delighted to cloak ignorance. Asiatic cholera is a filth disease, which is carried by dirty people to dirty places; it only develops where it finds dirty places in the sanitary sense, and dirty habits of drinking polluted water and living on a polluted soil.

We eat cholera and we drink cholera, and we catch the disease in this way, but apparently there is little, if any, basis for the belief that we catch it by infection, as in the case of measles or typhus fever. Even with all the exposure incumbent upon them, nurses, physicians, and attendants in cholera hospitals do not contract the disease in greater proportion than other members of a community. It is difficult to point to a single case in which the disease has been directly and indisputably communicated to an attendant where ordinary precautions are observed. When it breaks out on board a ship, the mortality from it is very great; and here the explanation is, as in other cases, to be found in polluted drinking water, not so much in direct conveyance of the disease from one person to another. Cholera is carried on the persons of individuals along lines of human intercourse, and is spread chiefly by the water supply becoming contaminated through the careless habits of those affected. The organism grows readily upon impure drinking water, and may live in it for months. Being so very minute, it readily disseminates itself, and finds entrance in the most insidious manner to cisterns and other receptacles of storage water.

TYPHLITIS AND PERITYPHLITIS (τυφλός, *cæcus*, and *itis*).

870. By *typhlitis* is understood an inflammation, usually catarrhal, of the caput cæcum. There is one special variety of catarrhal inflammation caused by the accumulation of a mass of hardened fæces in the caput cæcum, and to this the name is more particularly applied. The accretion becomes sometimes so great that atony of the coats of the intestine results with consequent failure to dislodge the mass. The mucous membrane consequently becomes inflamed and catarrhal. If the fæcal matter is not duly removed ulceration of the mucosa may result, a condition which if it spread to the muscularis is likely to bring about perforation.

Without there being actual perforation, the state of the bowel may set up a suppurative inflammation in the surrounding cellular tissue, ending in the formation of an abscess. This condition is known as **perityphlitis.** The abscess may point subsequently in the *iliac fossa*, or may open simultaneously here and into the *cæcum*.

Masses of fæcal matter or foreign bodies may similarly lodge in the **vermiform appendix** and set up a like condition in and around it. The appendix usually becomes adherent to the peritoneum, and hence a fatal perforation may be avoided.

WAXY DISEASE.

871. In all cases of general waxy disease the intestine will be found to have participated. The **ileum** is the part which suffers most, but, practically speaking, any part may show a brown reaction with iodine. The rectum is least often affected.

To the naked eye the intestine presents nothing peculiar when unstained, but, when iodine is applied, the mucosa assumes a dark brown colour. The **villi** are the chief seat of deposit, and these stand up from the surface as little *brown projections* readily visible with unaided vision or by means of a pocket lens. In the large intestine the stain is more diffuse.

Examined microscopically, the masses of amyloid are found in the interspaces round the blood-vessels of the villi. The vessels, as in other localities, are compressed consequently, and the circulation through them interrupted.

Both in this and in tubercular disease of the intestine or of the mesenteric glands, the absorption of fat suffers more than that of any other constituent, and the fæcal excreta have the characters of the fatty stool (Fr. Mueller, No. 49, 1887, ii. p. 277).

Method of Demonstration.—Inject the blood-vessels with Richardson's blue; stain with gentian-violet. .

VENEREAL AFFECTIONS OF THE INTESTINE.

872. In persons lending themselves to unnatural sexual intercourse, **chancres,** hard or soft, frequently show themselves upon the mucosa of the rectum or at the anus. In congenital syphilis, however, truly **tertiary deposits** are found at different parts. In most instances these take the form of a chronic fibrous condition located in patches, but in other cases condylomatous masses or gummatous nodules may be found or an eruption of miliary nodules.

WASTING OF INTESTINE.

873. Blaschko (No. 13, xciv. 1883, p. 136) describes two cases of atrophy of the intestine in which he found the ganglia and fibres of Meissner's and Auerbach's plexuses and their connections in a state of fatty degeneration.

TUMOURS OF INTESTINE.

874. **Polypi** are of frequent occurrence in the rectum and large intestine generally. They frequently become detached and are passed per anum. They vary in size from a pea up to that of a walnut or large orange. Whitehead (No. 6, 1884, i. p. 410) records a most remarkable case where an enormous multiple pedunculated growth was attached to the lower part of the rectum. On introducing the arm into the colon similar pedunculated growths could be felt, but of smaller size.

They are usually of fleshy consistence, and, on microscopic examination, are seen to be made up of a young fibrous tissue containing many fibro-blasts and numerous intestinal glands, which are often in a state of distension and filled with mucus. Some of them appear to be true **adenomata.** The tumour just referred to was probably of this nature.

Myomata are sometimes found in great abundance and growing from the muscularis.

Cancer frequently takes its origin from the mucosa. Its locality is more at the lower end of the large bowel than elsewhere, the rectum being perhaps the commonest site, the sigmoid flexure next in order.

Cylinder-celled cancer has been described occasionally both in the stomach and rectum. Laveran (No. 4, iii. 1876, p. 300) mentions the condition as one in which the cylindrical epithelium is arranged in gland-like circles enclosed in lacunæ of fibrous tissue. The tumour might have been mistaken for a polypus had a neighbouring lymph-gland not shown a deposit of the same type. In some parts it was like an *adenoma*, in others it presented the heterologous characters of a true cancer. Other secondary tumours were found in the great epiploon. The tumour was firmly fixed to the intestinal wall.

Sarcoma of the intestine is rare. When present it generally takes the form of a polypoid mass.

GAS CYSTS.

875. Gas cysts are met with occasionally in the vagina. They also occur very rarely in the intestine.

In a case which lately came under the notice of the author they presented the appearance of an eruption-like crop of rounded tumours, each about the size of a large pea and lying within the mucosa of the ileum. So sharply isolated and hard were they that at first they were supposed to be myomata. On cutting into them, however, they were found to be hollow. They were lined with a smooth and well-defined membrane and their contents were completely aeriform. The wall was thick, almost like that of a hydatid cyst.

For manner of formation see account given under Diseases of Female Organs of Generation, p. 420.

ENTEROLITHS.

876. It is rarely that concretions are found in the **stomach.** As a rule they lie in some part of the **small intestine.**

Kooyker, however (No. 49, 1887, ii. p. 269), described some time since a concretion-like mass in the stomach of a man. It weighed 885 grm., was 18 cm. long and 8 cm. thick; there were other two of smaller size. It left a dimple when compressed with the finger; it did not possess a nucleus; and had a fæcal odour. The tumour was composed largely of vegetable matter, and had simulated a cancer during life.

Those in the intestine are frequently taken for *cancerous tumours.* They lie quite loose in the intestine, but do not seem to be passed onwards. It is possible that they induce an atony of the muscular coat at the point where they are retained.

They are made up largely of *vegetable refuse* and *fæcal matter* bound into a mass by *lime salts.* A form common in Scotland in bygone times, and sometimes met with even yet, is the *oat-husk* concretion.

It is very light. Others are much more compact, and in their concentric stratification resemble the calculi found in the bladder.

They may possess a nucleus, consisting of a particle of foreign matter of some kind accidentally admitted into the intestine.

In the **horse** and **cow** intestinal concretions are very common and reach a great size. They often consist of hair bound together as before described. Porous foreign bodies swallowed by the cow, such as woollen articles of clothing, etc., may become petrified by being impregnated with lime salts and in course of time prove a cause of obstruction.

Intestinal Actino-mycosis and Anthrax. (See *Bacteriology.*)

Intestinal Animal Parasites. (See *Animal Parasites.*)

Literature on Diarrhœa and Dysentery.—**Abblart** (Parasitical Dysentery): Arch. de méd. nav., xl. 1883, p. 450. **Baginsky** (Path. and Therap. of Summer Diarrhœa): Cong. périod. internat. d. sc. méd. compt. rend., 1884, Copenh., 1886, iii. sect. de pédiat., p. 40. **Basch:** Arch. f. path. Anat., xlv. 1869, p. 204. **Bigelow** (Summer D. of Adults): Med. and Surg. Rep., Phila., xlii. 1880, p. 378. **Bird:** Tr. M. and Phys. Soc., Bombay, iii. 1840, p. 90. **Booker** (In Infantile Diarrhœa): Tr. Internat. M. Cong., ix. Wash., iii. 1887, p. 598. **Burkart** (Hæm. Infarct. in): Berl. klin. Wochnschr., ix. 1872, p. 311. **Du Cazal:** Diarrhée, Dict. encycl. d. sc. méd., xxix. 1884, p. 123. **Chuckerbutty:** Cases illustrating the Pathology of Dysentery, 1866. **Cornil:** Arch. d. physiol. norm. et path., v. 1873, p. 311; *also*, Bull. Acad. de méd., xix. 1888, p. 522. **Delafield:** Med. Gaz., N. Y., vii. 1880, p. 257. **D. and Dysentery:** Reps. San. Comm., Bombay, for 1871 to 1877; *also*, Reps. San. Comm., Central Provinces, for 1869 to 1875; *also*, Reps. San. Comm., India, for 1868 to 1877; *also*, Rep. San. Comm., N.W. Provinces, for 1871 to 1878. **Edis** (Imperfect Mastication as Cause): Practitioner, 1876, p. 291. **English** (Cholera Infantum): N. Y. Med. Rec., xxxiv. 1888, p. 165. **Fayrer** (Dysentery and Liver Abscess): Lancet, 1883, i. p. 855; *also*, Brit. Med. Journ., 1884, i. p. 1031. **Holt** (Mic. Exam. Intestine in Summer Diarrhœa of Infants): Med. News, Phila., lii. 1888, p. 644; *also* (Bacteria and Diarrhœal Diseases of Infancy), N. Y. Med. Journ., xlix. 1889, p. 405. **Kartulis** (Egyptian Dysentery): Arch. f. path. Anat., cv. 1886, p. 521. **Kelsch:** Compt. rend. soc. de biol., v. 1875, p. 3; *also*, Arch. de physiol., v. 1873, pp. 406, 573. **Kiéner and Kelsch** (Dysentery): Arch. de physiol. norm. et path., iii. 1884, p. 186. **Lesage** (Bacillus of Diarrhœa of Children): Arch. de physiol. norm. et path., 1888, i. p. 212. **Leslie** (Path. Anat. of forty-seven Cases): Tr. M. and Phys. Soc., Calcutta, vi. 1833, p. 64. **Little:** Tr. Roy. Acad. Med., Ireland, vi. 1888, p. 312. **Longstaff:** Brit. Med. Journ., 1880, i. p. 519; *also*, San. Rec., 1880-81, ii. p. 291. **Norman:** Tr. Roy. Acad. Med., Ireland, vi. 1888, p. 333. **Paget** (Intestine in Acute Diarrhœa): Trans. Path. Soc. Lond., xxxvi. 1884, p. 208. **Potter** (Summer Diarrhœa): N. Y. Med. Rec., xxxii. 1887, p. 45. **Prior** (Micrococci of Dysentery): Centralbl. f. klin. Med., iv. 1883, p. 273. **Sarrazin:** De la dysenterie des pays chauds dans ses rapports avec les maladies du foie, 1883. **Seibert** (Cholera Infantum): N. Y. Med. Rec., xxxiv. 1888, p. 153. **Sexton** (Cholera Infantum): Med. Reg., Phila., iii. 1888, p. 458. **Stein:** Med. Monatschr., N. Y., 1889, i. p. 123. **Tomkins** (Bacteriology of Summer Diarrhœa): Lancet, 1887, ii. p. 361; *also* (Summer Diarrhœa), Brit. Med. Journ., 1889, ii. p. 180. **Vacher** (Diarrhœa of Children): Brit. Med. Journ., 1885, ii. p. 439. **Virchow:** Arch. f. path. Anat., lii. 1871, p. 1. **Woodward:** Diarrhœa and Bacteria, 1878.

Literature on Croupous Enteritis.—**Bamberger** (Gastro-Enteritis through Ptomaines): Wien. klin. Wochnschr., 1888, i. p. 673. **Carter** (Croupous Enteritis): Trans. M. and Phys. Soc., Bombay, ix. 1887, p. 28. **Field:** Membranous enteritis, 1887. **Findley:** Am. J. Med. Sc., cxxxvii. 1875, p. 103. **Fish:** Med. and Surg. Rep., Phila., xlii. 1880, p. 417. **Goodhart** (Intestinal Casts): Trans. Path. Soc. Lond., xxiii. 1872, p. 98. **Kartulis** (Giant-amœbæ in Egyptian Enteritis): Arch. f. path. Anat., xcix. 1885, p. 145. **Nesemann** (Hæmorrhagic Diphtheria of Intestine): Arch. f. path. Anat., xxxv. 1866, p. 607. **Rajewsky** (Intestinal Diphtheria): Centralbl. f. d. med. Wissensch., xiii. 1875, p. 691. **Schwarck:**

Ueb. Croup u. Diphtheritis d. Darmkanals, 1880. **Siebenmann** (Diplococcus in Mucus-like Zooglœa Masses in Catarrh of Large Intestine): Cor.-Bl. f. schweiz Aerzte, xv. 1885, p. 366. **Weissenfels:** Ueb. Diphtherie d. Darms, 1868.

Literature on Asiatic Cholera.—**Babes:** Arch. f. path. Anat., xcix. 1885, p. 148. **Bellew:** History of the Cholera in India, 1884. **Bitter:** Arch. f. Hygiene, v. p. 241. **Cheyne** (Report on): Brit. Med. Journ., 1885, i. p. 821 *et seq.* **Cunningham:** Scientific Memoirs by the Medical Officers in the Army of India, v. 1890; and *Ibid.* vi. 1891. **Deneke** (New Cholera Spirillum): Deut. med. Wochnschr., xi. 1885, p. 33. **Dowdeswell** (Morphology): Lancet, 1890, i. p. 1419. **Dunham** (Chem. Reaction): Ztschr. f. Hygiene, ii. 1887, p. 337. **Van Ermengem:** Recherches sur le Microbe du Choléra Asiatique, 1885. **Finkler and Prior:** Deut. med. Wochnschr., x. 1884, p. 579. **Friedreich** (Morphology): Arb. a. d. kaiserlichen Gesundheitsamte, viii. 1892, p. 87. **Gamaléja** (Production in Rabbits): Comptes rend. Acad. d. Sc., cvii. 1888, p. 432; *also* (Metchnikoff's Spirillum), Ann. de l'Inst. Pasteur, ii. 1888, p. 482; *also* (Production in Rabbits): Verhandl. d. x. internat. med. Cong., 1890, Berl., 1891, ii. 3 Ab. p. 33. **v. Hovorka and Winkler** (New Means of distinguishing Koch's Organism from that of Finkler and Prior): Mitth. a. d. embryol. Inst. d. k. k. Univ. Wien., 1890, p. 10. **Klebs:** Ueb. Cholera Asiatica, 1885. **Klein and Gibbes:** Trans. of Committee of Secretary of State for India in Council (Blue Book, 1885); *also*, The Bacteria in Asiatic Cholera, 1889. **Koch:** Various works; see Eng. Transl. N. Syd. Soc., 1886, under "Bacteria in relation to Disease"; *also*, Brit. Med. Journ., 1884, ii. p. 403. **Koch and Gaffky:** Bericht ü. d. Thätigkeit, etc., der Cholera—Egyptian and Indian Commission, 1887. **Löwenthal:** Compt. rend. Acad. d. Sc., cvii. 1888, p. 1169. **Nicati and Rietsch:** Arch. d. physiol. norm. et path., vi. 1885, p. 72. **Pettenkofer:** Cholera, How to prevent it; *also*, Lancet, 1886, ii. p. 29; *also*, Zum gegenwartigen Stand d. Cholerafrage, 1887. **Pfeiffer** (Relationship of Metchnikoff's Vibrio and that of Asiatic Cholera): Ztschr. f. Hygiene, vii. p. 347. **Report of Second Cholera Conference at Berlin:** Brit. Med. Journ., 1885, i. p. 1011. **Riedel:** Die Cholera, Entstehung, Wesen und Verhütung derselben, 1887. **Schiller** (Duration of Organism on Fæcal Matter): Arb. a. d. kaiserlichen Gesundheitsamte, Berlin, vi. 1890, p. 197. **Stillé:** Cholera, Origin, History, and Prevention, 1885. **Wood:** Rep. Lab. Roy. Coll. Physicians, Edin., ii. 1890, p. 275.

Literature on Tumours of Intestine.—**Boettcher** (Intestinal Myomata): Arch. f. path. Anat., civ. 1886, p. 1. **Holtkamp:** Ueb. d. Polypen d. Mastdarms, 1886. **Sailer:** Sur Kenntniss d. Adenome u. Carcinome d. Darms, 1888. **Sheild** (Large Rectal Polypus): Trans. Path. Soc. Lond., xxxix. 1887-88, p. 130. **Whitehead** (Multiple Adenoma): Brit. Med. Journ., 1884, i. p. 410.

GENERAL LITERATURE ON PATHOLOGY OF THE INTESTINE.

Baginsky (Intestine in Child): Arch. f. path. Anat., lxxxix. 1882, p. 64. **Bailey** (Intestinal Concretions): Chicago Med. J., ii. 1859, p. 150. **Ball** (Intestinal Concretions): Tr. Acad. Med., Ireland, ii. 1884, p. 395. **Baumel:** Maladies de l'appareil digestif, 1888. **Baumgarten** (Syphilitic): Arch. f. path. Anat., xcvii. 1884, p. 39. **Blaschko** (Lesion of Sympathetic): Arch. f. path. Anat., xciv. 1883, p. 136. **Bode:** Ein Beitrag zur Kenntniss d. in d. normal. menschlichen Faeces vorkommenden niedersten organismen, 1887. **Bodenhamer** (Atony of Rectal Pouch): N. Y. Med. Rec., xxxv. 1889, p. 372. **Brand** (Chyle-Absorption): Biol. Centralbl., Erlang., iv. 1884-85, p. 609. **Carter:** On a Peyerian Lesion of the small Intestines apparently new, 1886. **Cooper:** A Practical Treatise on Diseases of the Rectum, 1887. **Cripps:** Diseases of the Rectum, etc., 1884. **Curling:** Diseases of Rectum. **Damaschino:** Maladies de voies digestives, etc., 1885. **Dejerine** (Cylindrical Epithelioma): Progrès méd., xii. 1884, p. 273. **Discussion on:** Ileus. Berl. klin. Wochnschr., xxvi. 1889, p. 358. **Dujardin-Beaumetz:** Diseases of the Stomach and Intestine, Transl., 1886. **Esmarch:** Die Krankheiten des Mastdarmes und des Afters, 1887; *also*, Lief. 48, Deut. Chirurgie. **Fenn** (Psilosis): J. Am. Med. Ass., Chicago, 1884, ii. p. 121. **Flint:** N. Y. Med. Rec., xiv. 1878, p. 201. **Girdner** (Hæmorrhoids): N. York Med. Journ., xxxix. 1884, p. 95. **Gosiner:** Die Magen-Leber-u.-Darmkrankheiten, 1887. **Hadden** (Concretions): Trans. Path. Soc. Lond., xxxix. 1887-88, p. 131. **Henry** (Hæm. Infarct.): Trans. Path. Soc., Phila., ix. 1880, p. 24. **Hofmann** (Composition of Intest. Gas): Wien. med.

Wochnschr., xxii. 1872, p. 601. **Jürgens** (Syphilitic Affections of Intestine): Berl. klin. Wochnschr., xvii. 1880, p. 677. **Kelsey:** The Pathology, etc., of Diseases of Rectum and Anus, 1884; *also* (Venereal Diseases of Rectum and Anus), N. Y. Med. Rec., xxx. 1886, p. 623. **Lannois and Lépine** (Absorption of Upper and Lower Parts of Intestine): Arch. de physiol. norm. et path., 1883, i. p. 92. **Marfels and Moleschott** (Absorption of Solid Particles): Wien. med. Wochnschr., iv. 1854, p. 817. **Moleschott** (Absorption of Solid Particles): Untersuch. z. Naturl. d. Mensch. u. d. Thiere, Frankf. a. M., ii. 1857, p. 119. **Mracek** (Syphilitic Affections of Intestine): Vierteljahrsschr. f. Dermatol. u. Syph., 1883, Hft. 2, p. 209. **Nothnagel:** Beiträge z. Physiol. u. Pathol. d. Darmes, 1884. **Oesterlen** (Absorption of Coal Dust and other Solid Particles into Circulation): Ztschr. f. rat. Med., Heidelb., v. 1846, p. 434. **Pitt** (Lymphoma of Intestine): Brit. Med. Journ., 1889, i. p. 652. **Salkowski** (Pigmentation in Disease of Intestine): Berl. klin. Wochnschr., xxvi. 1889, p. 202. **Saundby** (Inflammable Expired Air): Brit. Med. Journ., 1886, i. p. 420. **Schuchardt** (Tubercular Rectal Fistula): Samml. klin. Vortr., 1887, No. 296 (Chir., No. 92, p. 2753). **Spina** (Intestinal Absorption): Sitzungsb. d. k. Akad. d. Wissensch. Math.-naturw. Cl., 3 Ab., Wien., lxxxiv. 1881, p. 191. **Starr:** Diseases of Digestive Organs, etc., 1886. **Tappeiner** (Intestinal Gas): Ztschr. f. physiol. Chem., vi. 1881, p. 432. **Thin** (Psilosis or "Sprue"): Practitioner, Lond., xxxi. 1883, p. 169; *Ibid.* xxxix. 1887, p. 337; *also*, Psilosis or "Sprue," 1888. **Treves** (Lectures on Anatomy of Intestine): Brit. Med. Journ., 1885, i. p. 415 *et seq.* **Tuffier** (Hernias of Cæcum): Arch. gén. de méd., 1887, i. p. 641. **Virchow** (Epithelial Desquamation): Arch. f. path. Anat., xc. 1882, p. 559. **Voit and Bauer** (Absorption): Ztschr. f. Biol., v. 1869, p. 536. **Waldeyer** (Mycosis Intestinalis): Arch. f. path. Anat., lii. 1871, p. 541. **Watney** (Minute Anatomy): Proc. Roy. Soc. Lond., xxii. 1873, p. 293; *also*, Phil. Trans., clxvi. 1877, p. 451.

CHAPTER LXXVI

THE PANCREAS

FUNCTIONAL DISEASES.

877. SOME of the **functional diseases** of the pancreas have already been considered along with the disorders of digestion. It remains further to refer to the comparatively newly discovered disease, namely,

PANCREATIC DIABETES.

878. Diabetes mellitus sometimes accompanies disease of the pancreas; it invariably follows its excision in the lower animals. Among the diseased conditions which call it forth may be mentioned abscess, cancer, calculous obstruction of the ducts, and wasting of the gland from various causes.

Mere ligature of the duct of the gland in an animal does not excite it, but ligature of all the pancreatic vessels does.

It has been supposed that the cause of the diabetes after excision of the pancreas is the injury to the hepatic nerves incidental to the operation. This idea, however, has of late fallen into disfavour. The view that recommends itself to those who have worked at the matter experimentally is that the pancreas secretes a glycolytic ferment (Lépine and Barral—see various papers, No. 40, 1890-1891) which is absorbed by the lymphatics of the organ, and thus finds entrance into the blood-stream. When this is absent part at least of the sugar within the blood fails to be split up and is consequently shed in the urine. As bearing this out Minkowski (No. 43, xxix. 1892, pp. 90, 639) found that by inserting a piece of the excised pancreas under the skin of the abdomen after removal of the entire pancreas, the development of diabetes was retarded.

ORGANIC DISEASES.

DISEASES OF THE DUCTS.

879. **Ranula Pancreatica.**—The pancreatic duct sometimes becomes obstructed either from a *tumour of the duodenum* or neighbourhood or from the *impaction of calculi.* Like the parotid duct under these circumstances, it becomes distended.

The calculi found occluding the duct are comparable to those found in the salivary ducts, and are composed mainly of carbonate of lime. They are sometimes over an inch in length.

The **cysts** which form in the pancreas are developed out of the main duct or from its finer tributaries in the substance of the gland.

The effect upon the gland tissue of **closure of the duct** has been studied experimentally by Arnozan and Vaillard (No. 4, iii. 1884, p. 287). They came to the conclusion that ligature of the canal of Wirsung (main duct) determines the setting up of general dilatation of the ducts, destruction of the gland substance, and an excessive formation of interacinous cicatricial substance. What seems to happen is in all respects alike with that which follows in the liver when the bile duct is the seat of ligature.

The general result of observations (Cohnheim, Mueller, etc.) made on the functional effects of occlusion of the pancreatic duct seems to favour the view that in animals it causes very little disturbance. The absorption of starchy matter from the intestinal contents does not appear to suffer; that of meat seems to be somewhat reduced; but a higher percentage of fatty matters in the stools cannot be made out. According to Mueller (No. 49, 1887, ii. p. 277), it is doubtful whether *steatorrhœa* is an accompaniment of pure obstructive disease of the pancreas. The intestinal secretion seems to take on vicariously the abolished functions of the gland.

INFLAMMATORY AFFECTIONS.

880. The pancreas is very rarely a seat of inflammation; but inflammatory affections of its substance are not entirely unknown. Where acute inflammation has been found affecting the substance of the gland, local hæmorrhage has been a notable and peculiar feature associated with it. In some cases it goes on to suppuration and abscess. The abscesses are mostly small, about the size of a pea, and multiple. The suppuration appears to be septic in most cases.

A **cirrhosis** of the pancreas has occasionally been noticed.

FAT NECROSIS.

881. Ponfick (No. 13, lvi. 1872, p. 541) described a lesion by this name which he found in the **bone-medulla** of the large hollow bones

of an emaciated and dropsical young woman who died from empyema and wax-like disease. Within the medulla were numerous almost colourless masses, which from their size and configuration might have been mistaken for tubercles. They proved, on microscopic examination, to be portions of marrow which had undergone fatty degeneration, the resulting piece of tissue being filled with compound granular corpuscles.

Similar localised necroses are met with in the **abdominal fat** not very uncommonly, and the fat which is bound up with the **pancreas** sometimes becomes the seat of them. They are scattered widely through its substance, and, according to Balzer (No. 13, xc. 1882, p. 520), may cause death from hæmorrhage. Their pathology seems to be quite unexplained. (For further particulars consult papers mentioned in Bibliog.)

NEOPLASMS.

882. **Cancer** and **Adenoma** are the commonest, more particularly the former. It is often difficult to say whether a cancer invading the head of the pancreas has been primary in that organ or whether it has been secondary to a cancer of the duodenum. The tumour is almost always located in the head of the organ, a fact which would seem to favour the latter of these views. In some cases, however, the tumour appears to be primary.

Tubercular and syphilitic affections of the gland are almost unknown.

THE PERITONEUM.

INFLAMMATION—PERITONITIS.

883. The minute alterations of the membrane when inflamed have already been fully discussed (vol. i. Sect. 176). It remains simply to indicate the grosser features of the disease and its various causes and issues.

When acutely inflamed, the peritoneum becomes congested and opaque. That covering the bowel may be deeply congested with extravasations of blood in its substance. A coating of fibrinous lymph on the surface often renders the opacity of the membrane a still more striking feature.

The two chief issues are in the formation of **adhesions** and **suppuration.** The adhesions are brought about in the same way as adhesions of serous surfaces elsewhere. When suppuration occurs, the pus tends to bag in all the dependent pouches of the sac, and particularly in the pelvis. It must be borne in mind, however, that the suppuration may be partially distributed and that the pus may be pent up in parts of the abdomen other than those which are dependent.

When the adhesions become fibrous the consequent matting together of the bowel often induces disastrous effects by obstructing the onward passage of the contents. Sometimes the great omentum becomes rolled up in a *rope-like manner* and attached by its free extremity usually to the lower part of the anterior abdominal wall or to the peritoneum lining the iliac fossa. At other times *hard or cord-like adhesions* are found stretching between distant loops of intestine, or fastened on the one hand to the intestine, on the other to some part of the parietal peritoneum. A mass of bowel may slip under such bands and suffer strangulation.

The included loops of bowel come to be more and more loaded with fæcal matter until their return is rendered impossible without division of the constriction. They suffer extreme congestion, hæmorrhages take place into their coats, the glossy lustre of the surface vanishes, and the bowel becomes *gangrenous*.

Causes.—These are chiefly **perforation** of some part of the gastro-intestinal tract, with escape of fæcal matter or of the contents of the stomach, as in *typhoid fever* or acute *perforating ulcer of the stomach*. It is also a common sequela of *peritoneal tuberculosis*, *cancer*, or some other tumour disease. The *parturient woman* is liable to suffer from it for obvious reasons; and of course, as might be expected, it is often due to traumatic causes, as where the peritoneum is *wounded* from without.

The serous coat of the intestine alone, if left intact, appears to be sufficient to prevent septic contamination from the contents of the bowel. The same holds good often of the peritoneum covering a septic abdominal abscess.

Pathological Phenomena.—As a rule, the disease, in its acute form, is accompanied by great pain. It is, however, a remarkable fact borne out by a pretty common experience that, even when suddenly induced, as from traumatism, there may be excessive peritonitis without any manifestation of pain or even a rise in temperature —nothing, in short, to indicate the excessively morbid state of the membrane.

The author has seen a remarkable case, among others, of this kind where a man ran against a sharp rail in the dark and inflicted on himself an abdominal injury. The rail penetrated the lower aspect of the scrotum, passed up the sheath of the rectus abdominis muscle, and entered the abdomen close to the umbilicus. It carried with it a plug-like mass composed of the various articles of clothing which he wore at the time of the accident. This mass neatly torn off from the different garments was found lying free in the abdominal cavity surrounded by pus. There was also more or less general diffuse suppurative peritonitis. The man did not complain of pain, nor was there any rise in temperature; so that it was never even suspected that he suffered from the abdominal suppuration which caused his death. The case also shows the possibility of a foreign body lying within the abdominal cavity without exciting subjective inconvenience.

When a septic abscess bursts into the peritoneum, immediate, almost instantaneous, collapse may ensue. The cause of this is probably the rapid absorption by the peritoneum of the septic chemical products. The individual may rally, however, for a time and again pass into a state of collapse from the supervention of peritonitis.

Peritonitis has a most *depressing effect upon the heart*, most likely from the intimate association of the membrane with the ramifications of the vagus nerve.

TUBERCULOSIS.

884. It is often difficult to trace the source of tubercular infection in the case of the peritoneum. A woman, for instance, is delivered of a child; peritonitis follows and the lymph becomes cheesy; the tubercle bacillus develops within it; and a general tubercular eruption follows in course of time in various organs. Possibly the bacillus in such a case gains access to the abdomen through the Fallopian tubes, a very unlikely supposition, or is derived from the intestine.

In most instances of primary tubercular peritonitis there is no tubercular ulceration of the intestine, nor is there even enlargement of the follicular tissue. If ulceration of the mucosa is found in such cases it is usually secondary to a massive deposit of tubercle in the peritoneal coat and, it may be, is limited to one or at most two or three spots.

Primary *tuberculosis of the peritoneum* and *tubercular ulceration of the intestinal mucosa* are two different diseases, and are not usually associated. When there is tubercular ulceration of the mucosa the mesenteric glands certainly become enlarged and filled with gray tubercles, but the peritoneum, with the exception of that covering the bowel immediately opposite the ulcers, as a rule, is free from tuberculosis.

When a primary eruption of tubercle breaks out over the peritoneum it excites *peritonitis*. The peritonitis is of a subacute nature, so that it may not prove immediately fatal. Great fibrous adhesion of the bowel to adjacent viscera and to the parietal layer of peritoneum takes place. The whole of the abdominal viscera are matted together so that they can be excised almost as a solid tumour-like mass. Mixed up with the coils of the intestine and its adhesions are innumerable tubercles. They vary in size from a millet seed to that of a horse bean, and are mostly cheesy in the interior. On separating the adhesions more or less curdy pus may be found encapsuled by them. The tubercles tend to ramify over the capsule of the liver but not within its substance. They are very abundant on the under aspect of the diaphragm, where they evidently develop within the large lymphatic trunks in this situation. Other organs throughout the body may be tubercular or not.

CANCER.

885. In the majority of cases this is **secondary** to cancer of some abdominal organ. It is asserted, however, that an eruption upon the membrane of **primary cancer** is met with. The author has never seen such a case. The acquired mesoblastic peculiarities of the peritoneum seem to have so diluted any epithelial characteristics which it may be supposed to have inherited from its presumably hypoblastic descent (see *Malformations*) that the latter seldom assert themselves. But in the case of all cancerous tumours springing from the abdominal viscera, and more particularly where the tumour occupies the stomach or intestine, secondary cancer tumours are likely to be found in some part of the peritoneum. The **omentum** is a common seat of such secondary growths. They grow often first of all as pendulous almost polypus-like bodies from the appendices epiploicæ of the transverse colon. These fusing constitute a *hard transversely directed belt or band* easily felt through the abdominal wall, and with which the omentum is usually intimately bound up. The tumour has a great tendency to colloid degeneration.

LIPOMATA.

886. Sometimes the appendices epiploicæ are so loaded with fat that they constitute actual fatty tumours. They occasionally become strangulated, separate, and remain as free non-adherent masses in the peritoneal sac. Their presence does not seem to excite peritonitis, probably because their separation takes place aseptically.

Absorption of blood from the peritoneum, **Ascites, Hæmorrhage,** etc., are described in other connections. See *Transfusion, Dropsy, Pelvic hæmatocele,* etc.

GENERAL LITERATURE ON THE PANCREAS.

Antonelli (Digestion of Fat): Gior. internaz. d. sc. med., vii. 1885, p. 568. **Arnozan and Vaillard** (Experimental): Arch. d. Physiol. norm. et path., 1884, iii. p. 287. **Balzer** (Fat Necrosis): Arch. f. path. Anat., xc. 1882, p. 520. **Bourquelot** (Digestion of Fatty Substances): Journ. de pharm. et chim., xii. 1885, p. 530. **Clæssen**: Krank. d. Bauchspeicheldrüse, 1842. **Dickinson** (Cancer): L'pool Med.-Chir. Journ., viii. 1888, p. 85. **Fitz** (Pancreatitis): N. Y. Med. Rec., xxxv. 1889, pp. 197, 225, 253. **La Fleur** (Fatty Degeneration): Med. News, Phila., liii. 1888. **v. Gieson** (Fat Necrosis in P.): N. Y. Med. Rec., xxxiii. 1888, p. 477. **Harris and Tooth** (M.-Organisms and Pancreatic Digestion): Journ. Physiol., ix. 1888, p. 220. **James** (Pancreatic Dig.): Brit. Med. Journ., 1885, ii. p. 1012. **Kühn** (Primary Cancer in Childhood): Berl. klin. Wochnschr., xxiv. 1887, p. 494. **Litten** (Primary Sarcoma): Deut. med. Wochnschr., xiv. 1888, p. 901. **Seebohm** (Primary Cancer): Deut. med. Wochnschr., xiv. 1888, p. 777. **Virchow** (Ranula Pancreatica): Berl. klin. Wochnschr., xxiv. 1887, p. 248.

Pancreatic Diabetes.—**Harley** (Pancreatic Diabetes): Brit. Med. Journ., 1892, ii. pp. 9, 452. **Hédon**: Arch. de méd. expér. et d'anat. path., iii. 1891, p. 44. **Lépine and Barral**: Compt. rend. Acad. d. Sc., cx. 1890, p. 1314; *Ibid.* cxii. 1891, p. 146. **Minkowski**: Arch. f. exp. Path. u. Pharmakol., xxxi. 1893, p. 85. **Thiroloix**: Le diabète pancréatique, 1892.

GENERAL LITERATURE ON THE PERITONEUM.

Coe (Grouped Cells in Ascitic Fluid as Diagnostic of Malignant Disease): N. Y. Med. Journ., xlviii. 1888, p. 103. **Gairdner** (Peritonitis): Med. Times and Gaz., 1885, ii. p. 273. **v. Grumbkow**: Beitrag zur Aetiologie de Peritonitis, 1887. **M'Ardle** (Perforative Peritonitis): Tr. Roy. Acad. Med., Ireland, vi. 1888, p. 392. **Pawlowsky** (Peritonitis): Centralbl. f. Chir., xiv. 1887, p. 881. **Pernice** (Experimental Peritonitis): Riv. internaz. di med. e chir., Napoli, iv. 1887, p. 1. **Rosenberry** (Acute Peritonitis without Pain): Med. Age, Detroit, v. 1887, p. 29. **Terrillon** (Lipomata of Mesentery): Arch. gén. de méd., 1886. i. p. 257.

CHAPTER LXXVII

THE NERVOUS SYSTEM

MEMBRANES COVERING CENTRAL PARTS.

Anatomical Details.

887. THE membranes enveloping the brain and spinal cord may be said to be *two* in number—the dura mater and the pia-arachnoid.

The encephalic **dura mater** not only serves as a covering of the brain, but also fulfils the purpose of an internal periosteum to the skull. Many of its diseases bear out this periosteal relationship.

The **arachnoid** cannot be considered separately from the **pia.** The two form the adjacent walls of a sac, the subarachnoid space, and are united by a complete sponge work of retiform trabecular tissue. The walls of this sac and the trabeculæ uniting them are covered by endothelium, and the cavity is filled with lymphy liquid. The sac indeed is a huge lymph-cistern, subdivided by means of these trabeculæ into minor sacs. Blood-vessels ramify in its walls, and project into it so freely that effusions of all kinds poured out from them accumulate within it. As in the case of the pleura, disease affecting the one wall will almost always be found implicating the other.

INFLAMMATION OF THE MEMBRANES—MENINGITIS.

888. The term **meningitis** (μῆνιγξ, a membrane) is applied generically to inflammatory affections of any of the encephalic or spinal membranes; that of **pachymeningitis** (παχύς, thick) to the disease when confined to the dura, while that of **leptomeningitis** (λεπτος, slender) is employed when the disease has its seat in the pia-arachnoid.

Pachymeningitis.

889. When the disease is **acute** in its onset and in the course which it runs, it will be found, if not tubercular, to be septic. Com-

pound fracture of the skull, the wound made in trephining, disease of the ear, pyæmia, and so on, are the more immediate exciting causes. The membrane is not naturally prone to acute inflammation, and, if septic mischief is avoided, will bear considerable mechanical insult.

As might naturally be expected, the inflammation in septic cases ends in suppuration, and the pus is either discharged into the subdural space, or, separating the membrane from the bone, becomes more or less completely encapsuled between them.

The disease in its **chronic form** sometimes arises without apparent cause, but in a large proportion of instances is due to *tertiary syphilis*. The parietal and frontal regions are perhaps the commonest seats of the syphilitic deposit. A special variety of pachymeningitis, not necessarily syphilitic, is found affecting the upper cervical region.

The membrane is seldom universally thickened; more commonly the thickening occurs in patches. It is detached with difficulty from the calvaria. Examined microscopically, the thickening is seen to be due to excess of fibrous tissue; it is rarely that the inflammatory products suppurate.

Syphilitic pachymeningitis is usually accompanied by syphilitic disease of the bone. The bone may be merely roughened and indurated; it is more likely eroded internally, possibly to such an extent as to have caused actual perforation of the skull in some parts. The erosion may also spread from without inwards, but in such cases the membrane is secondarily affected; when the erosion is on the inner aspect the syphilitic disease will be found to have taken origin in the dura mater. The erosion often proceeds at several points simultaneously. Pus may accumulate under the scalp and a slough lay bare the disintegrating bone.

It happens occasionally that the syphilitic deposit is primarily implanted in the brain in the form of a gummatous tumour. This may become adherent to the dura.

The appearance of the dura mater where the disease has commenced within it is quite characteristic. Sclerous patches, varying in size from a sixpenny- to a penny-piece, or larger, are scattered over it at intervals. They are hardest at the centre, and when cut into their texture is seen to be densely fibrous, while probably one or more gummata lie embedded in the fibrous basis. The gummata are usually hard, flat, and circumscribed. The adjacent bone has the characteristic worm-eaten appearance of syphilitic affections of the skull (*q.v.*). When the erosion starts from without, the gap in the skull may be an inch or more in width. In such cases the dural membrane does not as a rule give way, but constitutes the floor of the ulcer.

According to Duret (No. 521, i. 1878-79, p. 29) the dura mater is highly sensitive to pain. Lesions of it cause pain and reflex spasm of the muscles of animal and organic life.

Leptomeningitis.

890. Disease of the pia-arachnoid may follow upon a variety of circumstances. The largest proportion of cases are due to **tubercle,** but any of those factors previously stated as being likely to excite a pachymeningitis may also cause an inflammation of the pia-arachnoid. Leptomeningitis is one of the dangers to be feared in ear disease, and in septic disease of the orbit after enucleation.

The inflammations of this membrane tend to run an acute course rather than to become chronic. They often end in suppuration, but if the individual die early, which is often the case, the effusion into the subarachnoid space will probably be found to be highly fibrinous.

In the **suppurative variety** the superficial vessels, and more particularly the veins, are seen to be engorged. They have a deep purple colour, and are swollen and tortuous. The convolutions are flattened and the sulci shallow, evidently from pressure; the ventricular fluid is copious. In the vicinity of the parts which are purulent the congestion is extreme, and the pus is seen lying beneath the arachnoid. On account of its being enclosed within the subarachnoid space it is not easily detached, and maintains its position even when the brain is placed under a gentle stream of water.

Course followed by the Pus.—When pus is poured out at the base of the brain as a result of meningitis, it does not diffuse itself generally throughout the entire subarachnoid space, but infiltrates certain definite localities and follows certain constant directions. Thus, behind, it is limited as a rule by a sharp line of demarcation running across the under aspect of the cerebellum. From this it spreads forwards, enveloping the medulla oblongata, pons, and district of the circle of Willis, and is continued into the two Sylvian fossæ, and into the commencement of the great longitudinal fissure.

In taking this course the pus is guided by the large *lymph-sacs* in the subarachnoid at the base of the brain, and occupies the same position as when these are artificially injected. As shown by Key and Retzius (No. 540, p. 93 *et seq.*), the largest of these lymph-sacs lies around the medulla and on the lower surface of the cerebellum, and they give it the name of "cisterna magna cerebello-medullaris." There are comparatively few trabeculæ within this sac; a probe can be inserted into it and readily moved about in its interior. During life it contains the greater part of the subarachnoid liquid at the base. Hence pus readily accumulates within it. At the line on the under surface of the cerebellum limiting its posterior boundary, the trabeculæ again become dense, the arachnoid and pia are consequently knit closely together, and the pus is thus prevented from spreading further backwards. From this huge sac there run forwards over the pons mainly three other sacs. These they name, from their positions, respectively "cisterna medialis pontis" and the two "cisternæ laterales pontis." The former surrounds the basilar artery, and is flanked on either side by a lateral sac. The medial sac passes forwards to end in a blind extremity.

Another sac occupying the middle line in front of these is the "cisterna chiasmatis." It lies underneath the optic chiasma, and is richly beset with trabeculæ. Passing out from this on either side are the two large "cisternæ fossæ Sylvii," diverging into the two Sylvian fossæ and receiving tributaries from the subarachnoid spaces of the neighbouring sulci.

The whole of these communicate, through the main sac around the medulla, with the subarachnoid space of the spinal cord, and can be injected from it. Hence the pus sometimes finds its way downwards into the spinal canal.

Tubercular Meningitis.

891. Tubercle, as beforesaid, is the commonest exciting cause of meningitis. Tubercular disease of the encephalic membranes, however, is rare in old age, or even in adult life. Hence meningitis of tubercular origin is almost exclusively confined to childhood and youth; it is of rare occurrence in persons above twenty-five years of age.

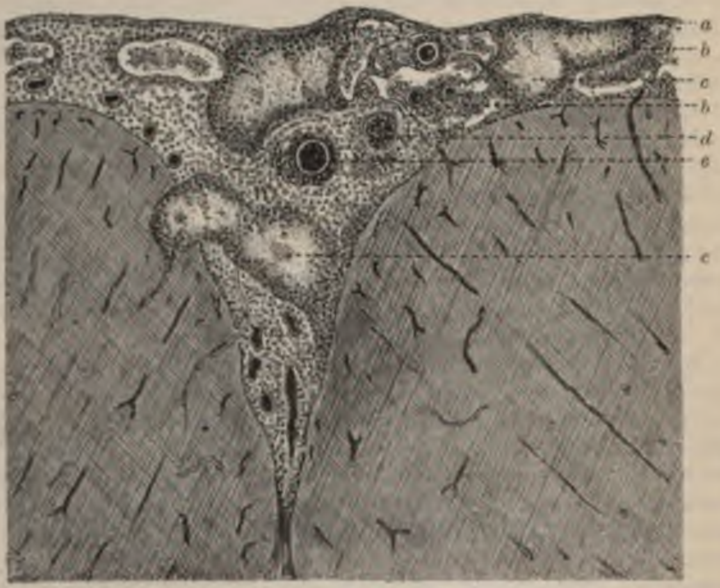


FIG. 415.—TUBERCULAR MENINGITIS (×50 DIAMS.)

(a) Arachnoid membrane with subarachnoid spaces (b, b) filled with inflammatory effusion; (c, c) tubercles in the subarachnoid trabeculæ; (d) congested blood-vessel; (e) blood-vessel with small-cell effusion round it (Picro-carmine and Farrants' Sol.)

It either manifests itself as part of a general disease, an acute tuberculosis of different organs, or is the result of auto-infection from a cheesy tubercular tumour located in the brain substance. The membrane affected is the pia-arachnoid. The dura mater may be held as almost exempt; it resembles the pericardium in this respect.

Sites.—The tubercles follow pretty closely the course of the blood-vessels. They are minute, seldom so large as a millet seed, and often microscopic. They have the gelatinous consistence and gray colour characteristic elsewhere of young tubercles. Their distribution is irregular, but certain localities seem more favourable to their development than others. Thus it is matter of common note that they are seen much more frequently at the base than at the vertex. The circle of Willis, the Sylvian fossæ and fissures, the surface of the pons, the lower aspect and sides of the cerebellum, are the parts in which they usually prevail. In fact it holds good as a general rule that *they are numerous in parts where the large arachnoid lymph sacs are located* (see Sect. 890).

Another site where they will be found pretty often is over the bases of the ascending frontal and ascending parietal convolutions. It is important clinically to remember that, when in this neighbourhood, twitching of the muscles of the face is a common indication of their presence. Even from three to four minute tubercles occupying the lower aspect of the motor area may call forth this phenomenon.

Appearances.—The vessels around the tubercles are in a state of acute hyperæmia, and where a tubercle holds an isolated position, where, for instance, a single tubercle overlies the operculum, a zone of hyperæmia will be found encircling it.

The base of the brain presents a characteristic appearance. The great lymph sacs in this situation are distended with fibrino-serous inflammatory effusion, so that the arachnoid is forced up, is stretched, and has a milky gray colour. Dimly protruding through this milky and opaque superstratum numbers of tubercles of different sizes are to be seen. They may be entirely hidden, however, if the effusion around them is abundant. The cranial nerves are frequently embedded in the effusion.

The ventricular liquid is abundant, and the convolutions, probably owing to the compression from this cause, are flattened and dry.

Examined microscopically, the tubercles (Figs. 415 and 416) present the same rounded shape and sharp border as elsewhere. If a piece of pia mater be stretched out on a slide the tubercles are seen to be clustered round the arteries like berries on the branches of a plant. Giant-cells may be discovered here and there, but there is usually an absence of reticular structure, probably from the disease having ended fatally before time has been afforded for this to develop. Their centres, however, notwithstanding the acute progress of the disease, are often caseous. The tubercles lie in the trabeculæ of fibrous tissue between pia and arachnoid, and a small artery is generally found embedded in their substance or lying at their side (Fig. 415, *e*).

Sometimes the artery is plugged by a thrombus (Fig. 416, *g*). The endothelium covering the trabeculæ in the neighbourhood is in a state of catarrhal germination, and is thrown off into the neighbouring spaces in the form of large, round, and highly nucleated cells (Fig. 416, *d*). Fibrin, leucocytes, and blood-serum also accumulate in the spaces, and it is the presence of these various elements combined which

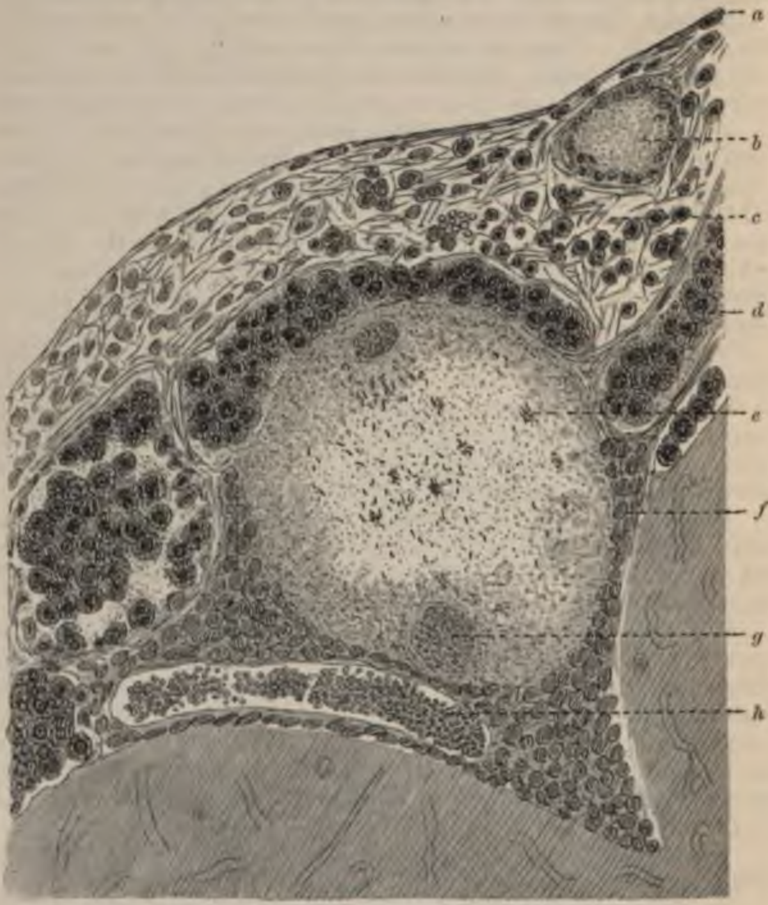


FIG. 416.—TUBERCULAR MENINGITIS (× 300 DIAMS.)

(*a*) Arachnoid; (*b*) small tubercle lying in the trabeculæ between arachnoid and pia; (*c*) effusion of fibrin and leucocytes into subarachnoid spaces; (*d*) accumulation of catarrhal endothelium in subarachnoid spaces; (*e*) tubercle bacillus lying in a tubercle of considerable size; (*f*) small-cell effusion; (*g*) small blood-vessel obliterated by a thrombus; (*h*) blood-vessel containing blood-corpuscles (stained in Picro-carmine and mounted in Farrants' Solution to demonstrate the surroundings; subsequently unmounted, washed, and stained by Ziehl-Neelsen solution of Fuchsin, and clarified to demonstrate the bacillus).

is the cause of the stretching and milky opacity of the arachnoid referred to above. The tubercle bacillus (Fig. 416, *e*) is sometimes abundant within the tubercles, and is not difficult to demonstrate. It has been found in the effusion poured out into the subarachnoid lymph-sacs.

Meningitis from Ear Disease.

892. It is seldom that disease of the ear or of the mastoid cells occasions a diffuse meningitis. More commonly there is a slight slough of the dura over the tympanum, with or without adhesion of the pia-arachnoid; while only patches of lymph are seen on the inner aspect of the dura mater, accompanied or not by abscess of the neighbouring brain substance.

Pitt (No. 6, 1890, i. p. 644) found that in ten out of twelve cases of temporo-sphenoidal abscess from ear disease there was sloughing of the dura localised to the above site, and that diffuse meningitis was caused mostly by an abscess of the brain rupturing.

Sometimes there is great difficulty in tracing the connection between the ear disease and an abscess of the brain evidently due to it. There may be a layer of sound brain tissue intervening even in the presence of a meningitis with perforation of the middle or internal ear. Pitt holds that, when this is so, the channels of infection are *veins* which empty themselves from the temporo-sphenoidal lobe into the superior petrosal sinus. The sinus may be in a state of septic phlebitis. In other instances, the *lymph-channels* convey the septic matter. When there is a localised adhesion of the brain to the petrous bone the infection spreads directly.

In instances of mastoid disease the lateral sinus becomes thrombosed, a condition very apt to excite pyæmia.

Toynbee was of opinion (1) that affections of the external meatus and mastoid cells excite disease of the lateral sinus and cerebellum; (2) that affections of the tympanic cavity occasion disease of the cerebrum; and (3) that affections of the vestibule and cochlea give rise to disease of the medulla oblongata. According to Pitt (No. 6, 1890, i. p. 643), if meningitis follow disease of the internal ear, the posterior fossa of the skull is usually the seat of it. When an abscess forms in the cerebrum as a result of ear disease, the temporo-sphenoidal lobe will in most cases be found to be the region in which it is located. The abscess may be of such size as to destroy the entire lobe. The walls present a peculiarly sloughy character and have a grayish-green colour.

Epidemic Cerebro-Spinal Meningitis.

893. The disease which goes by the above name is by many physicians regarded as a specific fever of which meningitis is a local manifestation. It shows itself epidemically in various countries both in the new and old world, and appears to be distinctly infectious.

The thin membranes of the cord are the seat of vascular congestion, with effusion of a liquid, varying from a turbid serum to one which is distinctly purulent, into the subarachnoid space of the brain and cord, with occasionally a similar effusion into the cerebral ventricles.

Vital Phenomena of Meningitis.

894. These in the commencement are usually of the nature of pyrexia followed in course of time by signs of implication of the cranial nerves or cortical motor centres. The motor oculi nerves, and more especially the third, lie embedded in the very focus of the disease, in the basilar form, and hence squint or some abnormality of the pupil is a common symptom. Optic neuritis, for a similar reason, is frequently an indication of the disease. Stimulation of a particular cortical centre by isolated tubercles has already been referred to (p. 571). In course of time, however, symptoms of brain-pressure follow, due most likely to serous effusion into the ventricles, a phenomenon discussed elsewhere (Sect. 905). The accompanying headache may most likely be ascribed to this.

Literature on Meningitis.—**Adamkiewicz**: Pachymeningitis hypertrophica and chronic infarct. of spinal cord, etc., 1890. **Bramwell** (Cerebro-Spinal): Lancet, 1878, i. p. 9. **Greenfield** (Simple): St. Thomas' Hosp. Rep., viii. 1878, p. 143; *also* (Tubercular), Lancet, 1874, i. pp. 833, 904. **Henoch**: Charité-Ann., xi. 1886, p. 575. **Hutchinson** (Direct Traumatic Arachnitis): Med. Times and Gaz., 1875, i. pp. 519, 547. **Sievers**: Om meningitis cerebro-spinalis epidemica, Helsingfors, 1886. **Wieting** (Meningo-Myelitis): Beitr. z. path. Anat. u. z. allg. Path., xiii. 1893, p. 411. **Ziemek**: Zur Kenntniss der Meningitis cerebro-spinalis epidemica, 1885.

OTHER AFFECTIONS OF THE MEMBRANES.

895. In various chronic diseased conditions of the spinal cord **calcareous plates** about the size of a lentil or smaller are found upon the arachnoid. A feasible explanation of their presence has not as yet been given.

The dura mater is sometimes the seat of origin of tumours of the connective tissue class, such as **fibromata, sarcomata,** or **endotheliomata.** The last of these often takes on cylindromatous characters. The flat cells are arranged in a tesselated fashion around the minute blood-vessels (Fig. 132). Secondary cancers occasionally grow from it. More commonly they arise in the brain, and subsequently become attached to the dura.

VENTRICULAR GRANULATIONS.

In chronic diseases of the brain of different kinds the lining membrane of the ventricles sometimes presents a fine roughness, owing to minute granulation-like projections from its surface. They appear to be entirely cellular and are devoid of blood-vessels.

MORBID CHANGES IN THE HISTOLOGICAL ELEMENTS.

Ganglion Cells.

896. **Hypertrophy.**—There is, strictly speaking, no such condition, but in acute inflammation the ganglion cells, more especially the large motor cells of the anterior horn of gray matter in the cord, become enlarged, and to this the term is sometimes applied. Their protoplasm at the same time assumes a granular aspect, their outline is indistinct, and their angles are blunted. Meynert supposed that the condition was due to *œdema*; it looks more like a *cloudy swelling* similar to that so often seen affecting the tubular epithelium in inflammatory affections of the kidney, and in the liver-cells in many different morbid states of that organ.

Shrinking.—Diminution in size, shrinkage, and ultimate destruction is a process met with in many diseases of the brain and cord. In *infantile paralysis* the ganglion cells of the anterior horns, and in *glosso-labial palsy* those of the nuclei of the hypoglossal, pneumogastric, etc., undergo shrinkage and finally vanish.

Pigmentation.—Impregnation of nerve cells with brown hæmatoidin occurs in many diseases, especially where they run a chronic course. The first alteration noticed in the cells of the nerve nuclei just mentioned as being implicated in glosso-labial palsy is this pigmentary deposit in their protoplasm. It is frequently associated with shrinkage.

Vacuolation.—Whitwell (No. 521, xii. 1890, p. 520) has described a condition of vacuolation of the nucleus occurring mostly in those demented. The large pyramidal nerve cells of the fronto-parietal convolutions are prone to suffer from it. The nucleus of the cell either swells into a single transparent globose body, or several small vacuoles develop within it. The degeneration often seems to precede a pigmentation of the cell. The affected cells stain deficiently or irregularly with aniline-blue-black.

Fatty Degeneration.—There is no alteration so prevalent in diseases of the central nervous system as fatty degeneration. The oil globules show themselves usually first at one end of the cell, often aggregated in a mass. When seen in an unclarified preparation they present the usual highly refractile appearance of oil. When clarified, however, the individual oil globules vanish, and a yellow transparency of the affected part of the protoplasm is all that remains to indicate the lesion.

Calcification.—Ganglion cells and their processes have occasionally been found infiltrated with lime salts, but the degeneration is not a common one.

Proliferation.—Notwithstanding that it has often been asserted to the contrary, there seems no reason to believe that nerve cells ever proliferate. There is no evidence of new nerve cells ever being generated by this means. Indeed there is every reason for concluding that the nerve cells of fœtal life are those which prevail throughout an animal's entire existence. Once destroyed, they never seem to be replaced. Appearances held to be demonstrative of multiplication of nerve-cell nuclei are deceptive, and may be the result of colloid alteration of their protoplasm.

Nerve Fibres.

Fatty Degeneration.—When a nerve fibre is separated from its trophic nerve cell it suffers from fatty or, as it is called, "Secondary" or "Wallerian" degeneration throughout the entire course of the distal segment. When a part of the brain becomes ischæmic, as from embolism, the deficient supply of blood leads to a fatty degeneration, in which the nerve fibres are involved.

Enlargement of Axis-Cylinders.—This is a most remarkable form of degeneration, found as a rule in inflammatory foci both in the spinal cord and in the brain. It is also seen in the nerve fibres of the retina.

The lesion consists in an irregular contraction of the axis-cylinders, whereby swellings appear in their course which impart to them a moniliform appearance (Fig. 421). These swellings are usually oval in shape and homogeneous in consistence. The individual masses in course of time separate from each other, and sometimes a tail-like appendage is found adhering to one end. They next appear to split up into a number of smaller round or oval-shaped, homogeneous, corpuscle-like bodies. These so-named "colloid bodies" in most respects resemble the "amyloid bodies" found so frequently in the cord and brain, but fail to give their reactions. They seem to perish by undergoing fatty degeneration. (For further particulars see Myelitis and Cerebritis.)

Calcareous Degeneration.—This has already been referred to as occurring in nerve cells and their processes. It may also extend sometimes to the actual nerve fibres (Virchow and Förster).

Diseases of the Connective Tissue.

Sclerosis (σκληρός, *hard*).

Definition.—This term is applied to a condition in which there is an overgrowth of the connective tissue, the neuroglia, of the brain or cord.

The neuroglia contains, it will be remembered, numbers of connective tissue cells. Most of them have large nuclei and are branched; the term "spider cell" or "Deiters' cell" is applied to those which are branched. When the brain or cord becomes sclerosed the glia cells increase in number. Their nuclei multiply, and this is followed by division of the cell itself. The new cells may be branched even more than the originals; sometimes, however, they remain unbranched. They tend to develop into fibrous tissue.

There are several varieties of sclerosis, among which the following may be noted:—

Systemic Sclerosis.—In the spinal cord of locomotor ataxia, for instance, the sclerosis follows the posterior columns from below upwards, and in many instances is confined to these columns. The lateral columns may similarly be the exclusive seat of a sclerosis limited to the crossed pyramidal tract.

Diffuse Sclerosis.—When a tumour develops within one of the cerebral hemispheres some amount of enlargement usually takes place within that hemisphere. The enlargement is uniform and diffuse, and is strictly confined to the hemisphere in which the tumour is situated. It is caused by an overgrowth of the neuroglia. The "spider cells" increase in size and number to a marvellous extent, and by their interlacing processes constitute a complete felt-work. The overgrowth of the connective tissue does not at first seem to destroy the nerve fibres. They may be seen coursing through the midst of the network.

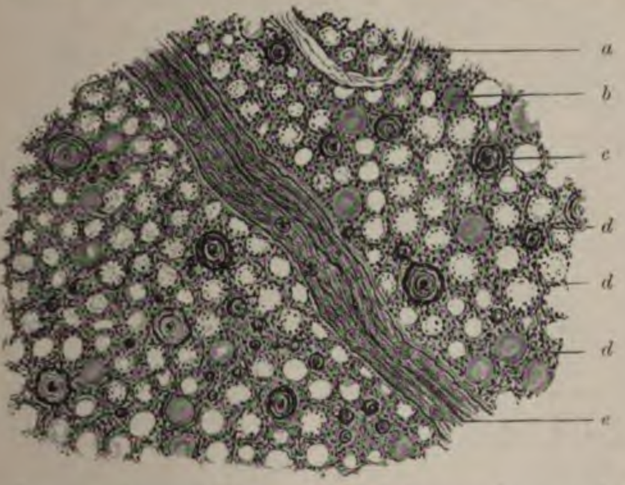


FIG. 417.—TRANSVERSE SECTION OF PART OF A POSTERIOR COLUMN IN LOCOMOTOR ATAXIA, SHOWING THE SCLEROSIS OF THE NEUROGLIA (×350 DIAMS.)

(*a*) Small blood-vessel; (*b*) amyloid body; (*c*) remains of a nerve tube partially degenerated; (*d*, *d*, *d*) the sclerosed neuroglia surrounding empty nerve tubes; the fine points are glia-fibres cut across; (*e*) the interfunicular artery (Perosmic acid and Farrants' Sol.)

Sometimes this diffuse overgrowth of the connective tissue occurs without apparent cause, the condition being usually termed **Hypertrophy of the Brain.** An extraordinary case of this kind is recorded by Tuke (No. 5, vii. 1873, p. 257) in the person of a man. The right hemisphere of the cerebrum was much enlarged, very tough, and weighed 30¼ ounces; while the left, which was of natural size, weighed only 23½ ounces. The specific gravity of the two was alike. The basal ganglia did not appear to have participated in the enlargement. The gray matter was more voluminous than usual on the affected side. The calvaria was dilated in accordance with the unilateral enlargement. The increase in size was not the result of hypertrophy of the brain tissues proper, but was caused by an overgrowth of the glia.

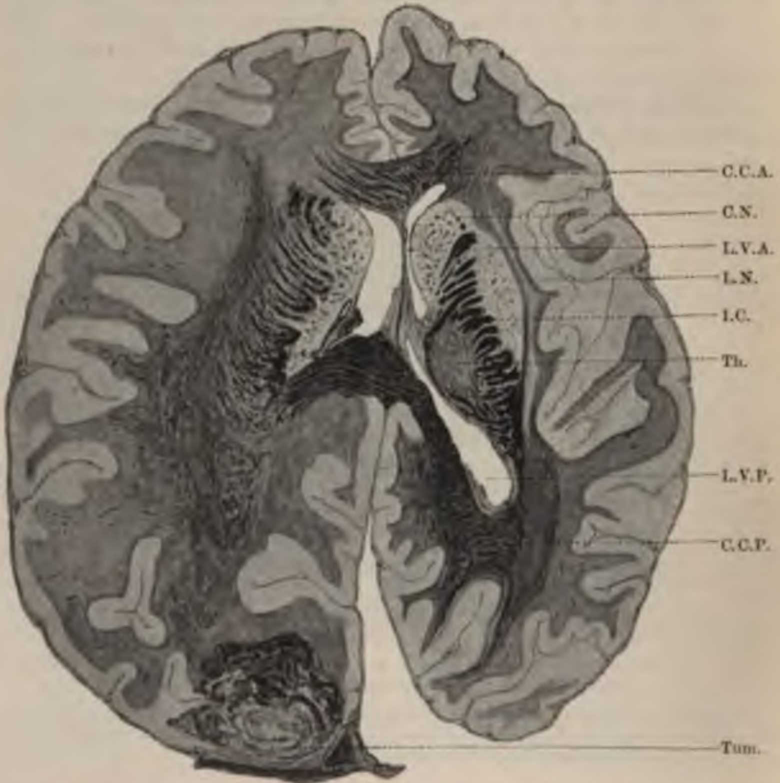


FIG. 418.—HYPERTROPHY OF CEREBRAL HEMISPHERE ACCOMPANYING A TUMOUR IN THE OCCIPITAL LOBE.

(C.C.A.) Corpus callosum anteriorly; (C.N.) caudate nucleus; (L.V.A.) lateral ventricle, anterior horn; (L.N.) lenticular nucleus; (I.C.) internal capsule; (Th.) thalamus opticus; (L.V.P.) lateral ventricle, posterior horn; (C.C.P.) corpus callosum posteriorly; (Tum.) tumour (endothelioma) situated in the occipital lobe.

A similar overgrowth of the glia has been noticed by Strümpell (No. 517, ix. 1879, p. 268), where the brain was abnormally small.

Multiple or Insular Sclerosis.—This is a special variety of sclerosis affecting the brain and cord, and characterised by the overgrowth being localised to irregularly-shaped patches. There appear to be two varieties of it, one where the patches are soft or myxoma-like in character, another where they are dense and hard. It seems probable that the mucoid variety may be a further advanced stage of the sclerous. (For further information see Sect. 974.)

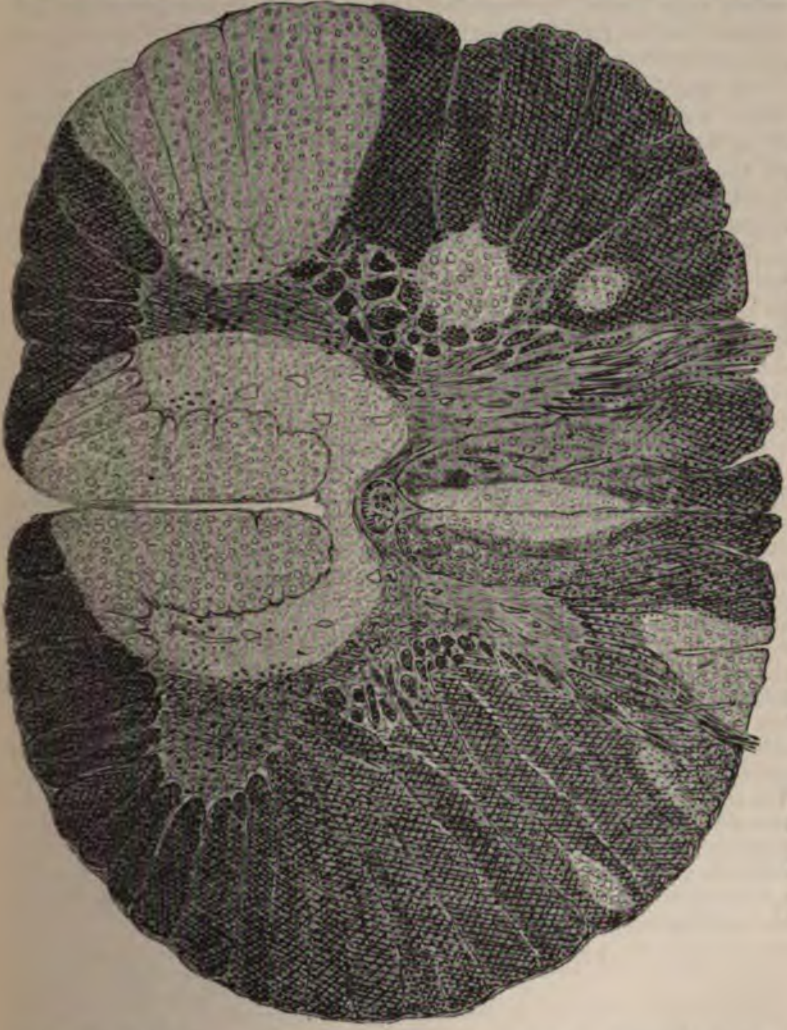


FIG. 419.—MULTIPLE OR INSULAR SCLEROSIS AFFECTING THE CERVICAL CORD (Logwood and Clarified).

Hyaline or Colloid Condition.

Over and above the mucoid patches just referred to as being found in disseminated sclerosis, multiple colloid masses are occasionally seen, mostly in the cortex of the brain, which may bear a certain relationship to them. The colloid-looking substance in question seems in most cases to be deposited round the blood-vessels, and spreads outwards from these. It resembles the amyloid closely in its general appearance, but fails to give the characteristic reactions. There is good evidence for believing that it is the result of cellular degeneration.

A peculiarly dense form of sclerosis is met with in the brain which seems to precede the appearance of the colloid. It consists in a tumour-like hardening of portions of its substance, usually of the cortex. The margin of a convolution may thus feel sometimes like a piece of cartilage. The author has seen it in chronic epileptics. The masses are not large, are irregular in shape, and are multiple. They are often associated with a similar cartilage-like induration of the medulla oblongata, a condition more fully referred to in Section 973. The cells of the sclerous tissue break down subsequently into the colloid. Holschewnikoff (No. 13, cxii. 1888, p. 552) describes a case of multiple colloid tumour of the brain where, in addition to the above method of development, the new tissue seemed to arise from the coats of the blood-vessels.

A good example of this colloid condition is described by Simon (No. 517, ii. 1870, p. 64). It occurred in the person of a woman of dissolute life, but without direct evidence of having had syphilis. She lived to sixty-four years of age and did not suffer from any symptoms indicative of the extensive lesion of which she was the subject. Throughout the entire gray mantle of the cerebral hemispheres there were numerous hyaline areas of a gray-violet to a bright lilac colour. They recalled the appearance of hyaline cartilage, and had a breadth of from 2 to 4, a depth of from 1 to 2, and a thickness of from 1·5 to 3 m.m. They were confined entirely to the gray substance, and appeared all to commence between gray and white matter, and to press later on into the former. The cerebellum, pons, medulla oblongata, and spinal cord were free from them. The patches differed in this respect from those of insular sclerosis. They were also more hyaline and had a violet tint. The outer area of the patch was fibrillar and contained numerous branched glia cells. The centre was hyaline, and within it the nerve cells seemed to lose their branches, and to be in process of conversion into the hyaline. The blood-vessels were unaltered; the walls of the capillaries were not thickened, but were surrounded by numerous glia cells, from which the fibrous network seemed to spring. He does not say whether reagents were applied with the view of ascertaining whether or not the hyaline substance was waxy.

Wax-like Disease.

The wax-like infiltration is certainly not often met with in the central nervous system or peripheral nerves. There is, however, a *post-mortem* condition which closely resembles it. It has already been described (Sect. 129). Many of the so-called amyloid bodies appear also to arise in this way, although others, such as those of the cord in locomotor ataxia, are truly vital productions.

Diseases of the Blood-Vessels.

897. Those affecting the arteries are mainly *atheromatous* and *obliterative arteritis*, *simple fatty degeneration*, and *miliary aneurism;* but as each has already been described under *Diseases of the Arteries* (Chap. XLIII.), it is unnecessary to refer to them further at present.

Thrombosis of the cerebral sinuses is not very uncommon. Those which are the seat of it are chiefly the great longitudinal and the lateral. It generally follows a phlebitis affecting the interior of the sinus wall, and, in most cases, is septic in its origin. Thrombosis of the lateral sinus is usually the result of disease of the ear or of its mastoid cells. When pyæmia sets in from ear disease, it appears to be associated with thrombosis of this sinus.

The thrombus either fits closely into the interior of the sinus, or it lies more or less detached and surrounded by pus. The lateral sinus may be completely occluded by a firm thrombus running from end to end.

Diseases of the Lymph-Vessels.

898. Under the designation "État criblé" Parchappe and Durand-Fardel described a peculiarly porous condition of the brain substance. The affected part, sieve-like, is permeated with minute apertures. It is at first difficult to understand how the condition is to be accounted for, but the explanation given by Arndt (No. 13, lxiii. 1875, p. 241) seems to throw some light on it. He makes out that the apertures are dilatations of the lymph spaces intervening between the adventitia of the blood-vessels and the brain substance—the so-called "lymph spaces of His."

Literature on Diseased Conditions of the Histological Elements.—**Anton** (Disturbances in Growth of Surface of Brain): Ztschr. f. Heilk., vii. 1886, p. 453. **Arndt** (État Criblé): Arch. f. path. Anat., lxiii. 1875, p. 241; *also* (Axis-Cylinders), Arch. f. path. Anat., lxxviii. 1879, p. 319. **Brunet** (Granulations of Ependyma): Ann. méd. psych., Par., iv. 1886, p. 54. **Fox**: Path. Anat. of Nerv. Centres, 1874. **Fürstner and Stühlinger** (Gliosis and Formation of Cavities): Arch. f. Psychiat., xvii. 1886, p. 1. **Greenlees** (Recent Researches on Gen. Par. of Insane): Brain, xi. 1888-89, p. 246. **Holschewnikoff** (Hyaline Degeneration of Brain Vessels): Arch. f. path. Anat., cxii. 1888, p. 552. **Pick** (Cystic Degeneration): Arch. f. Psychiat., xxi. 1889-90, p. 910. **Popov** (Regeneration of Ant. Comm.): Vrach., vii. 1886, p. 682. **Raymond**: Anat. pathol. du syst. nerv., 1886. **Roth** (Varicose Axis-Cylinders): Arch. f. path. Anat., lv. 1872, p. 208. **Schultze**: Arch. f. path. Anat., lxviii. 1876, p. 109; lxxiii. 1878, p. 443; lxxix. 1880, p. 124; lxxxvii. 1882, p. 510. **Sharkey** (Cases in which no Naked-Eye Changes found): Lancet, 1885, i. p. 1028. **Simon** (The Spotted Glassy Degeneration of Cortex): Arch. f. Psychiat., ii. 1869, p. 64. **Virchow** (Granulations in Wall of Ventricle): Allg. Ztschr. f. Psychiat., iii. 1846, p. 242; *also* (Fatty Degeneration), Arch. f. path. Anat., x. 1856, p. 407. **Whitwell** (Nuclear Vacuolation): Brain, xii. 1889-90, p. 520. **Zacher** (Nerve Fibres in Gen. Par. of Insane): Arch. f. Psychiat., xviii. 1887, p. 60.

PORENCEPHALIA.

899. By this is understood a condition following upon absorption of parts of the brain, and occurring during intra-uterine life, in which

a peculiarly porous or sponge-like fibrous texture takes the place of the brain substance.

According to Kundrat (No. 560), the destruction of the brain substance is not occasioned by hæmorrhage or embolism, but is due to ischæmia and the malnutrition resulting therefrom. The true nerve basis gradually disappears by absorption, while the blood-vessels and connective tissue framework remain, constituting a porous network. The blood-vessels are in a thickened condition. The destruction usually commences deeply in the white matter of the brain; the cortex may be affected later on. Sometimes, however, the cortex is preserved, while a porencephalous cavity underlies it.

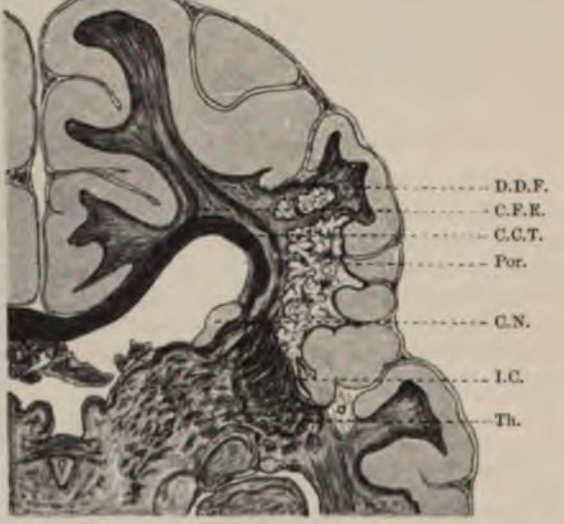


FIG. 420.—PORENCEPHALIA AFFECTING LATERAL ASPECT OF CEREBRUM (Natural Size).

(D.D.F.) Direct descending fibres; (C.F.E.) fibres entering corpus callosum from vertex; (C.C.T.) crossed callosal tract, consisting of those fibres which have crossed in the corpus callosum, and which are descending in the inner capsule; (Por.) porencephalous destruction; (C.N.) caudate nucleus; (I.C.) inner capsule; (Th.) thalamus opticus (gelatine-potash method).

ENCEPHALITIS (CEREBRITIS) AND MYELITIS.

900. It has been alleged that cerebritis never occurs without being accompanied by meningitis. There is a good deal of truth in this statement. The pia mater, being the vascular membrane, is affected either widely on its superficies or in the portions which dip into the brain substance. It is wrong, however, to say that meningeal complication is invariable. Foci of inflammation and suppuration may be found embedded deeply in the white matter of the brain without the pia mater being involved.

The Acute Form.

Characteristic Appearances.—In bygone times many lesions unconnected with inflammation were described as indicative of a cerebritis or a myelitis. Thus embolic softening, secondary degeneration, etc., were previously included in the category of inflammatory diseases. There is even yet much dubiety as to the classification of the sclerotic diseases—whether they should be called inflammatory or not.

Some years ago the author (No. 9, xv. 1875, p. 335) made an experimental inquiry into the subject of myelitis with the view of ascertaining what appearances were characteristic of it when artificially induced. They were found to be as follows:—

If the spinal cord is artificially stimulated, as by passing a thread through it, inflammatory reaction begins to show itself within a few hours. The appearance of the pial sheath is alike with that of any other inflamed vascular membrane.

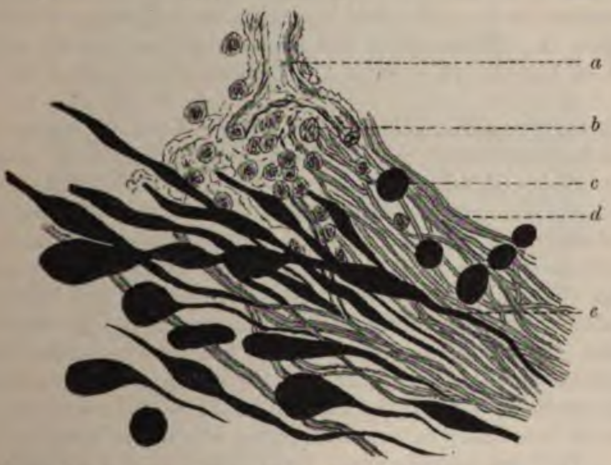


FIG. 421.—ACUTE MYELITIS INDUCED IN THE SPINAL CORD OF THE CAT, AND SHOWING THE SWOLLEN AXIS-CYLINDERS. The portion of tissue represented is taken from the anterior commissure.

(*a*) Small blood-vessel; (*b*) leucocyte; (*c*) swelling on axis-cylinder cut across; (*d*) unaltered medullated nerve fibre; (*e*) moniliform swellings on axis-cylinders.

The vessels become engorged, and from them there exude numberless leucocytes, while extravasations of blood, the result of the engorgement, are noticed here and there. These phenomena are best seen on the surface of the cord, but also prevail in the septa of pia mater which extend inwards.

The most remarkable and characteristic appearances, however, are to be found in the nerve tubes, and more particularly in the axis-cylinders.

The axis-cylinders, according to Schiefferdecker (No. 14, xxx. 1887, p. 458), are made up of a delicate sheath externally, which is easily ruptured. Within this are contained fluid or semi-fluid albuminous contents. It is questionable whether the axis-cylinder is fibrous, although it has been asserted by Arndt and others to be so. The alterations it suffers in inflammation seem to support the view of its being homogeneous. A contraction takes place in its length whereby it becomes broken up into fragments (Fig. 421). The fragments are converted into spherical or oval-shaped homogeneous masses (*c*), and several of these may, at first, be united in a moniliform fashion (*e*). A complete separation, however, follows, so that the space in the glia which formerly contained the medullary sheath and axis-cylinder now holds a number of these homogeneous colloid bodies. The space, as a consequence, is dilated and the medulla vanishes. Sometimes the colloid body possesses a tail-like appendage at one end, so that it might possibly be mistaken for an altered nerve cell. The alteration in the axis-cylinders makes its appearance within a few hours after the inflammation has commenced, and is very evident at the end of two to three days. It is most evident round the seat of injury.

A further transformation now ensues. Vacuoles appear in the contracted axis-cylinders, and bodies like nuclei are often perceptible in their midst. Arndt (No. 13, lxiv. 1875, p. 372), taking the view that the axis-cylinders are fibrillar, states that within the swellings the fibrillæ disappear. Where they go to he cannot say. He refers to the nuclear bodies above mentioned. Virchow had previously seen and described these nuclear bodies. Sometimes they are homogeneous like myeline drops, at other times they possess a nucleolus-like object in the centre. It is quite possible that they are simply modified vacuoles.

The large homogeneous colloid masses in course of time split up into multiple smaller masses of the same consistence. As many as twenty or thirty of these may be met with lying in a single space in the glia matrix. They are usually about twice the size of a blood-leucocyte. They have been named "colloid bodies." They are morphologically identical with amyloid bodies, except that they are not so often concentrically striated. In some instances, however, even such striation may be noticed. They differ from them, however, *toto cœlo* in the fact that the colour tests, which are so readily elicited in the case of true amyloid bodies, fail in their case.

For long they may remain as "colloid bodies." In course of time, however, and more particularly if the inflammation has gone on to suppuration, they appear to fall into a state of fatty degeneration, and when in this condition closely resemble pus corpuscles which have met a similar fate.

Zenker (No. 518, ii. 2, 1856, p. 142) appears to have been the first to notice these varicose axis-cylinders. He found them in the retina. His observations were confirmed by Müller (No. 518, iv. 2, 1858, p. 42). Virchow (No. 13, xliv. 1868,

p. 475) found them in areas of brain substance softening from encephalitis. Roth (No. 13, lv. 1872, p. 207) was of opinion that in the retina they were indicative of inflammation, and Berlin (No. 518, xiii. 1867, p. 294 ; also, *Ibid.*, xiv. 1868, 2, p. 281) showed that they could be called forth in the retina by artificially stimulating it. They appear in from one to sixteen days after the stimulus has been applied. Grohe and Roth are said to have produced them artificially by injuring the brain of the rabbit. The author's own experiments (No. 9, xv. 1875, p. 335) were the first to demonstrate their presence in the artificially inflamed spinal cord. Leyden (No. 535, ii. p. 129) regards them as indicative of an inflammatory affection.

In Man huge collections of such "colloid bodies" derived from the axis-cylinders may be found in the midst of inflammatory foci of the brain and cord (Fig. 422). Their origin from the axis-cylinders can best be studied at the margin of the inflammatory area, where they can be seen lying in rows corresponding to the original axis-cylinders. Within the focus of inflammation itself they are amassed, many of them being still pyriform and having a tail-like appendage at the narrow end—the remains of the axis-cylinder from which they took their origin. In circumscribed syphilitic inflammations of the brain they are sometimes present in great quantity. They have been noted by Schulze, Strümpell, Küssner, and Brosin in the human cord affected with myelitis.

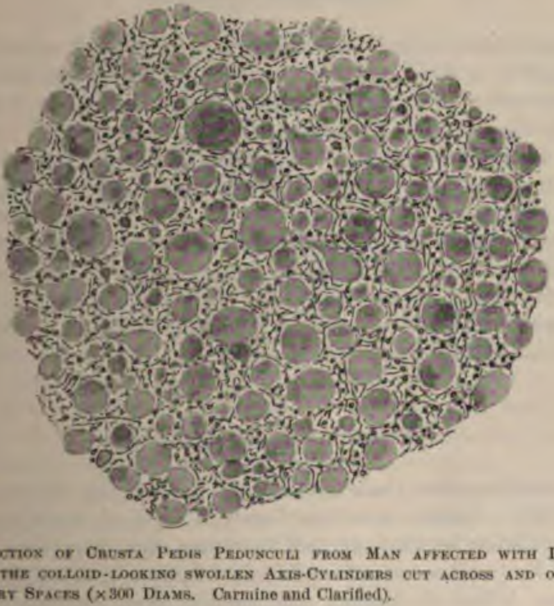


Fig. 422.—Section of Crusta Pedis Pedunculi from Man affected with Inflammation, showing the colloid-looking swollen Axis-Cylinders cut across and occupying the Medullary Spaces (×300 Diams. Carmine and Clarified).

The neuroglia usually shows evidence of proliferation, more particularly if the area stimulated remains aseptic and does not suppurate. Its spider cells become polynucleated, enlarge, and divide, and the new cells thus formed often show characteristic karyokinetic appearances (Friedmann).

The alterations suffered by **the nerve cells** are of a purely retrograde character; cloudy swelling of their substance, with contraction and division of their processes, is often met with. They never seem to respond to the stimulus by multiplying. Popoff (No. 13, lxiii. 1875, p. 421) alleged that wandering cells find their way into nerve cells in the encephalitis following typhoid. He said that he found the same phenomenon in myelitis induced experimentally. He also alleged that the protoplasm of nerve cells is capable of absorbing particles of cinnabar and other foreign particulate substances.

The Chronic Form.

Whether the so-called scleroses are to be traced to inflammatory causes or not is a much-debated question. If they are so it is somewhat curious that in many instances they follow definite tracts in the cord and in the central parts above.

When a tumour is located in a hemisphere of the cerebrum, the whole of the hemisphere often undergoes enlargement from an overgrowth of the neuroglia (p. 577). Is this to be regarded as a chronic inflammation? It is difficult at present to answer the question.

In epileptics an almost cartilaginous hardness of the medulla oblongata is sometimes met with. It is caused by an overgrowth of fibrous tissue running chiefly along the blood-vessels. Whether this is to be considered as inflammatory in its origin is also questionable.

ABSCESS OF THE BRAIN.

901. Abscess of the brain from ear disease has already been referred to (Sect. 892). It sometimes lies deeply, a layer of healthy brain substance intervening between it and the bone, and may be so large that it occupies the entire temporo-sphenoidal lobe or a hemisphere of the cerebellum. When the abscess has reached such dimensions the sac has become single. It contains green or gray coloured pus, and its wall is more or less sloughy.

It may happen that the abscesses are multiple, and when so they are generally caused by a pyæmic state of body.

A *blow on the head*, without fracture of bone, may cause an abscess to form in the brain substance; at least the author has seen a case where the abscess could not otherwise be accounted for.

In *typhoid*, *diphtheria*, and other diseases multiple foci of inflammation may show themselves, which proceed to suppuration. It has been stated that multiple minute abscesses of the brain cortex account for some cases of *chorea*.

Literature on Myelitis and Encephalitis.—**Banham** (Myelitis with Calculus in Ureter): Lancet, 1886, i. p. 737. **Buss** (Acute Dissemin. Myelitis Bulbi): Deut. Arch. f. klin. Med., xli. 1887, p. 241. **Friedmann** (Inflammation of Nerves and Ganglion Cells): Arch. f. Psychiat., xix. 1887, p. 244; *also* (Enceph.), Arch. f. Psychiat., xxi. 1889-90, p. 461 *et seq.* **Hamilton:** Quarterly Journ. Mic. Sc., xv. 1875, p. 335. **Hayem** (Enceph.): Arch. de physiol. norm. et path., i. 1868, p. 401. **Herter** (Experimental Myelitis): Med. News, Phila., liv. 1889, p. 221. **Huguenin** (Enceph.): Handb. d. spec. Path., xi. 1876, p. 329. **Letzerich** (Enceph. Diphtheritica): Arch. f. path. Anat., lxv. 1875, p. 419. **Leyden** (Chronic Myelitis and System Diseases): Centralbl. f. Nervenheilk. u. Psychiat., iii. 1892, p. 153. **v. Limbeck** (Congenital Encephalitis): Ztschr. f. Heilk., vii. 1886, p. 87. **Meyer and Bayer:** Arch. f. Psychiat., xii. 1882, p. 392. **Obermeier** (Varicose Axis-Cylinders): Arch. f. path. Anat., lviii. 1873, p. 323. **Roth** (Varicose Hypertrophy of Nerve Fibres): Arch. f. path. Anat., lv. 1872, pp. 197, 517; lviii. 1873, p. 255. **Strümpell** (Enceph.): Deut. Arch. f. klin. Med., xlvii. 1890-91, p. 53. **Virchow** (Enceph.): Arch. f. path. Anat., xliv. 1868, p. 472; *Ibid.*, xxxviii. 1867, p. 129.

SYPHILITIC AFFECTIONS.

902. Many of the inflammatory affections of the central nervous system are of syphilitic origin. According to Virchow and others, the commonest form which syphilitic inflammation takes is that of a basilar meningitis. Oppenheim (No. 537, p. 2) describes the disease under such circumstances as being concentrated in the vicinity of the optic chiasma. The subarachnoid space in this locality looks as if filled with a coagulated fluid such as paraffin or celloidin. This penetrates into all the neighbouring fissures, and the origins of the cranial nerves and the optics and motores oculi are more especially embedded in it. The nerves themselves may be altered and swollen, and on section present a glassy lustre, or are gray to a bacon-yellow in colour. There are, nevertheless, cases where the nerves are quite healthy. The optic tract, the oculomotors, and the fifth nerve may be involved in a tumour-like mass of new tissue. The remainder of the brain may be intact, or may show hæmorrhages and softening, most often located in the basal ganglia; while in some parts gummata may be found.

The gummata vary in size; they often lie near the surface, in which case the dura is usually adherent to them. Huge cheesy masses sometimes occupy the cerebellum. They may be traceable to syphilis, but in most instances will be found to be tubercular. As already described under diseases of the dura mater, gummata are located occasionally in this membrane.

The arteries are very frequently involved, the most characteristic form of disease from which they suffer being *arteriitis obliterans* (see vol. i. p. 664).

Sometimes, however, this affection of the vessels gives rise to local foci of inflammatory softening. The softened part may have a reddish-brown colour, hence the term **red softening** formerly applied to the lesion. The crus cerebri and pons may exhibit such a focus.

Syphilis and Tract Lesions.—It can hardly be denied, in face of the evidence favouring the view, that a good many of the tract or system lesions of the spinal cord owe their origin to syphilis. Thus a large proportion of those who are the subjects of locomotor ataxia have a syphilitic history (see *Locomotor Ataxia*). There are other forms of tract sclerosis which, as indicated both by the history and by the nature of the lesion, are traceable to no other cause. Such, for instance, is a case recorded by Rumpf (No. 517, xvi. 1885, p. 410), where a man eleven months after acquiring syphilis began to suffer from hemiplegia and other symptoms pointing to implication of the cord. After death it was found that he was the subject of degeneration of both crossed pyramidal tracts and of the tracts of Goll, accompanied by a syphilitic condition of the spinal blood-vessels.

Period of Advent.—The time at which the cerebral lesion shows itself after the primary affection has been variously estimated. Gowers (No. 6, 1889, i. p. 235) gives the following, drawn up from fifty cases which came under his own observation, exclusive of those above forty-five years of age:—

1 to 2 years	9 cases
3 ,, 5 ,,	7 ,,
6 ,, 10 ,,	9 ,,
11 ,, 15 ,,	11 ,,
16 ,, 20 ,,	4 ,,

There was an interval of nineteen years in a man who had syphilis at eighteen. The shortest interval was three months; in another case the attack occurred six months after infection. In others the time could not be definitely determined.

Vital Phenomena.—By far the commonest manifestation is *hemiplegia*, a fact pointing to disease of the middle cerebral artery. Local paralysis of the cranial nerves, those concerned with the movements of the eyeballs and upper eyelids in particular, is highly significant, when supported by collateral facts, of a localised syphilitic lesion. Where a focus of syphilitic softening is located opposite the origin of the fifth nerve, excessive neuralgia on the same side of the head may constitute the most prominent indication of the disease.

Literature on Syphilitic Affections of Nervous System.—**Althaus** (of Membs. of Brain): Arch. f. Psychiat., xvi. 1885, p. 541. **Baumgarten**: Arch. f. path. Anat., lxxxvi. 1881, p. 179. **Bramwell** (Intracranial Syphilis): Studies in clin. med., Edin., i. 1889-90, p. 2. **Charcot and Gombault**: Arch. d. physiol. norm. et path., v. 1873, pp. 143, 304. **Cornil**: Leçons sur la syphilis, 1879. **Daly** (Arteries): Brain, viii. 1885-86, p. 392. **Dowse**: Syphilis of Brain and Sp. Cord, 1879. **Erb** (Syph. Spinal Paralysis): Neurolog. Centralbl., xi. 1892, p. 161 **Fournier**: Union méd., Nos. 62, 65, 69, 76, 79, 84, and 87 for 1884. **Gajkiewicz**: Syphilis du système nerveux, 1892. **Gerhardt**: Berl. klin. Wochnschr., xxiii. 1886, p. 1. **Gowers** (Gulstonian Lectures on Syphilis and Nervous System): Brit. Med. Journ., 1889, i. p. 57. **Greenfield** (Arteries): Trans. Path. Soc. Lond., xxviii. 1876-77, p. 249. **Heubner**: Die luetische Erkrankung d. Hirnarterien, 1874; *also*, Cycl. Pract. Med. (Ziemssen), xii. 1877, p. 293. **Hutchinson**: Med. Press and Circ., xxxvii. 1884, pp. 371, 394. **Oppenheim**: Zur Kenntniss d. syph. Erkrank. d. central. Nervensystems, 1890. **Rumpf**: Die syph. Erkrankungen d. Nervensystems, 1887; *also*, Arch. f. Psychiat., xvi. 1885, p. 410. **Schmaus** (Primary Syph. Arteriitis in Sp. Cord): Sitzungsb. d. Gesellsch. f. Morphol. u. Physiol. in München, iv. 1888, p. 115. **Siemerling** (Congenital Syphilis): Arch. f. Psychiat., xx. 1888, p. 102. **Virchow**: Ueb. d. Natur d. constitutionell-syphilitischen Affectionen, 1859.

CHAPTER LXXVIII

THE NERVOUS SYSTEM—(*Continued*)

CIRCULATION WITHIN THE BRAIN AND SPINAL CORD.

903. As we are now about to consider a set of lesions in whose pathology the blood-vessels play an essential part, a few general remarks on the circulation within the brain and spinal cord may not be inapplicable.

The Encephalic Blood-Supply.

The arteries within the brain are of two kinds: (1) those which anastomose, and (2) those which are terminal. As shown by Heubner (No. 327), there is a free communication between the various arteries coursing over the surface of the organ within the pia mater. Hence these are far from being terminal. When coloured injection is driven into any of the main stems coming off from the circle of Willis, it soon runs into the secondary branches emulging from them. The secondary branches divide into a close network within the pia, which is in communication with all other branches on the surface of the hemisphere, so that, from any one tributary, the entire arterial system on the surface can be readily filled. The injection passes at first rapidly through the main stems, and it is only when these have become distended that the network in the pia begins to fill. From the pial network fine branches run into the brain substance. Most of them split up in the gray matter, but a few of them are longer and penetrate into the white. The gray matter is thus much more vascular than the white.

The pial network may accordingly be regarded as a safety reservoir. Exacerbations of pressure drive the blood rapidly through the main stems, but the ill effects on the brain of this sudden afflux are warded off by the increased blood being accommodated in the pial network.

The cortical supply of arteries is therefore freely anastomotic. It is quite otherwise with the branches which perforate the base of the brain, and which, passing upwards through the perforated spaces, supply the basal ganglia and intervening capsules. These appear to be perfectly terminal, and hence, when occluded, the parts supplied by them die. They come off, it will be remembered, from the vessels entering into the formation of the circle of Willis, and are the following:—

1. The antero-median branches leaving the anterior cerebral close to the anterior communicating artery and supplying the head of the caudate nucleus alone.

2. The antero-lateral branches springing from the middle cerebral close by its origin and supplying the great part of the caudate nucleus, the entire lenticular nucleus, a portion of the thalamus, and the whole of the inner capsule. The importance of these branches is accordingly very great.

3. The postero-median branches given off at the bifurcation of the basilar and irrigating the inner aspect of the optic thalamus.

4. The postero-lateral branches taking origin from the posterior cerebrals and distributed throughout the choroid plexus, the external and posterior regions of the thalamus, nearly the whole of the wall of the lateral ventricle, the corpora quadrigemina, and the superior portions of the crura cerebri.

According to Duret (No. 4, i. 1874, p. 60) there is a complete anatomical separation between the branches given off from the circle of Willis to the two sides of the brain. Not only so, but even although the communication is free in the circle, the blood-supply of the two hemispheres is in a manner unconnected. Thus Schultén (No. 96, xxxii. 1885, p. 463) by an ingenious device made out that when one carotid is tied, the pressure within the ophthalmic artery of the same side sank 20-30 to 40 mm. Hg., while that on the opposite side remained unaltered. This is one of the great causes of death after ligature of the carotid.

In summing up the substance of an elaborate paper upon the circulation within the cranium, Lewy (No. 13, cxxii. 1890, p. 146) draws the following corollaries:—

1. The regulation of the supply of blood to the brain follows the same laws as in other parts of the body—that is to say, widening of the arteries up to a certain limit causes increase, narrowing of them decrease of the blood stream passing through them.

2. Venous turgescence occasions arterial anæmia, and acute pressure of the brain from any cause brings about a like result.

3. Widening of the arteries beyond a certain limit, as, for instance, through inflammatory stimulation, brings about arterial anæmia—that is to say, less blood passes through them.

The Blood-Supply of the Spinal Cord.

904. It will be remembered that the chief source of the arterial supply to the cord is from the spinal branches of the vertebral in its

ascent, and from the anterior and posterior spinal arteries given off from it on a level with the medulla oblongata. The two anterior spinals unite to form the anterior median artery, running the entire length of the cord, and anastomosing with the spinal branches of the vertebral above referred to, as well as with branches of the inferior thyroid, intercostal, and lumbar arteries. The plexus thus formed ramifies in the spinal pia mater, from which subsidiary branches are given off to the cord.

The veins unite in a rich plexus constituted by the veins of the bodies of the vertebræ, the anterior longitudinal spinal, and the posterior longitudinal spinal. They anastomose freely, and those emerging at first hand from the cord ramify in the pia mater side by side with the arteries. Through their abundant anastomosis they ultimately pour their blood, above, into the vertebral and inferior cerebellar trunks, and perhaps also into the inferior petrosal sinus, and, below, into the lumbar, the intercostal, and the vertebral veins by communications formed through the intervertebral foramina.

The ultimate distribution of the arteries and veins to the cord in Man, according to Adamkiewicz (No. 12, lxxxiv. H. I., Ab. III. 1881, p. 469) is as understated :—

From the anterior median artery of the cord are given off great numbers of branches which pass into the anterior median sulcus. He calls these *arteriæ sulci.* They split upon the anterior commissure, a branch being supplied to each anterior cornu. These two branches lie in wide spaces hollowed out in the anterior commissure. They are known as the *art. sulco-commissurales.*

In the lower dorsal and upper lumbar regions, and more particularly opposite Clarke's vesicular columns, branches separate from the above, which are distributed to Clarke's columns (*art. columnarum Clarki*).

Short branches also arise from the same stems close by the commissure, which run upwards and downwards in the anterior horns of gray matter. An anastomosis takes place between the branches of both sides through the commissure.

After the separation of the above-named branches, the art. sulco-commissurales split into their terminal subdivisions in the gray matter. Two or three of such are to be seen, one going to the anterior, another to the posterior horn ; whilst, if there be a third branch, it is usually distributed to the part of the gray matter intermediate between the two. An abundant plexus of capillaries is furnished from these various sources. It is poorest in the neighbourhood of the commissure, and is entirely wanting round the central canal.

The main venous stems belonging to the above system are almost identical in distribution, and for these Adamkiewicz adopts very much the same nomenclature.

The above is, however, only one system of blood irrigation. The remainder is constituted by the plexus of arteries and veins running in from and to the pia mater, the so-called **vasocorona.** The vessels of this system are :—

(1) *The marginal branches* which simply dip in for a short distance ; and (2) *the vessels of the white substance.* The latter pass in radially for a greater distance, but not as far as the gray matter. They supply branches which run upwards and downwards in a longitudinal direction between the bundles of fibres. One of these, the *arteria fissuræ,* enters the posterior fissure distributing branches on either side. Its branches are mostly given off before the posterior commissure is reached, although a few are distributed to it. This vessel is richer in offshoots than any

other branch of the vasocorona. The arteriæ fissuræ finally penetrate the posterior gray horns, and splitting into numerous capillaries, nourish the gray matter, more especially that in the neighbourhood of Clarke's columns.

Important branches of this second system are also the *art. interfuniculares* piercing between Goll's and Burdach's columns and supplying them with offshoots. They are most evident in the cervical swelling. From the middle of the dorsal region downwards their place is taken by the ordinary vessels of the corona.

(3) The remaining branches of the coronal series are those which, passing radially through the white, are distributed to the border of the gray matter. They irrigate the border zone of the gray matter.

Brain Pressure.

905. **Definition.**—By this is meant *the pressure to which the brain, or rather the entire central nervous system, is subjected by the subarachnoid fluid and that of the ventricular system.*

This pressure is said to be *directly* increased when the quantity of subarachnoid fluid is augmented, *indirectly* increased when the intracephalic space is diminished (Falkenheim and Naunyn, No. 104, xxii. 1887, p. 292).

Distribution of the Cerebro-Spinal Liquid.

There appears to be very little liquid in the subdural space; it is even alleged that the arachnoid lies in direct contact with the dura. The cerebro-spinal liquid is contained mostly in the subarachnoid space. Communications exist between this space and the ventricles through the foramen of Magendie and the aperturæ laterales ventriculi quarti (Key and Retzius). It is rare to find a hydrops of the subdural space; the liquid usually accumulates in the subarachnoid.

The cerebro-spinal liquid also communicates with the venous lacunæ of the dura through the Pacchionian bodies or granulations; and by other less well-known paths with the lymphatics of the head, and specially with those of the nasal mucous membrane.

A free communication exists between the cushion of liquid surrounding the spinal cord and that which envelops the brain. As showing the freedom of this communication Naunyn and Schreiber (No. 104, xiv. 1881, p. 4) find that, when a cannula is inserted into the subarachnoid space of the posterior spinal region, and another into the subarachnoid space of the brain through a trepan opening in the skull, pressure applied to the contents of the skull through the corresponding cannula is almost immediately transmitted to the cannula within the spinal canal until the pressure in the two situations is equalised. Pressure applied in the opposite direction, that is to say, from below upwards, is not transmitted so rapidly.

The Normal Pressure of the Cerebro-Spinal Liquid.

There is manifest difficulty in ascertaining this in Man. Quincke (No. 208, xxi. p. 465), however, found that within a lumbar meningocele in a child eleven weeks old it came up to 4 mm. Hg. (54 mm. H_2O); and in a four months' child to 12 mm. Hg., rising to 20 mm. on the child crying. Bergmann (No. 523, Lief xxx. p. 293) under like conditions found it to amount to 15 mm. Hg. during narcosis, and 22 mm. when the child was crying.

Vital Phenomena induced by varying the Pressure.

The method of raising the brain pressure employed by Naunyn and Schreiber (*loc. cit.*) was that of injecting $\frac{3}{4}$ per cent salt solution into the subarachnoid space. With various modifications it is the means generally employed for the purpose.

The degree of pressure is estimated either by passing a manometer up to the base of the skull through the ligamentum occipito-atlantoideum, or by using an apparatus tightly adjusted to a trepan opening in the vault of the skull. The pressure must reach a certain height before symptoms begin to show themselves. This point is not absolute, but is dependent upon the blood pressure within the carotid. In no case is the rise lasting where the means of inducing it are suddenly applied, as by compression of the channel of the aorta. In from one to two minutes after the increase has been noticed a fall occurs. It is due to absorption of part of the cerebro-spinal liquid.

Pain is admittedly the first result of an elevation of pressure, and supervenes under a comparatively slight increase, that is to say, when the pressure is raised to 70-80 mm. Hg. With a greater pressure it disappears. The cause of the pain Naunyn and Schreiber ascribe to stretching of the dura mater and to anæmia of the brain. This is important as probably explaining certain forms of **headache.**

Next in sequence come **convulsions.** A pressure of 80-100 mm. Hg. gives rise regularly to them. They are most likely due to anæmia of the cerebral motor centres, and are consequently analogous to those seen in an animal bled to death. They occur before any slowing of the pulse is noticeable.

The **circulatory phenomena** are the following: All observers are agreed that an elevation of brain pressure beyond a certain point induces a retardation of the pulse. This is accounted for by the stimulation of the vagus centre in the medulla oblongata. The phenomenon fails when the vagi are divided. More especially is the slowing of the pulse noticed when the pressure is severe and long continued. A pressure even of 200 mm. Hg., however, fails to induce it when the vagi are divided, or when their terminations are paralysed by atropin (Naunyn and Schreiber).

Towards the *exitus letalis* **the pulse** increases in rapidity owing to the vagus centres becoming paralysed. This quick pulse is usually a sign of sinking.

The effect of increased brain pressure upon the general arterial pressure throughout the body is thus summarised by Schultén (No. 92, xxxii. 1885, p. 742). His experiments were made upon dogs and rabbits :—

(1) So long as the brain pressure is less than the minimum height of the original blood pressure, and what Marey calls the "constant pressure," it does not exert any appreciable influence upon the blood pressure.

(2) If the brain pressure rises above the minimal blood pressure an elevation in the blood pressure constantly follows ; the pulse becomes slow. This holds good for the maximum as for the minimum height of the same.

(3) When the brain pressure again falls the blood pressure also falls, but when the former sinks below the original minimal, the latter, after a minute or two, reaches its original type and level.

(4) When the amount of pressure applied to the brain is raised much above the original blood pressure, the blood pressure in turn tends as a rule to rise above that of the brain. There are individual idiosyncrasies as to the point at which this occurs. In every case, however, there is a border at which the arterial pressure no longer follows that of the brain. He explains this occurrence by the influence exerted by the vaso-motor centre in the medulla oblongata upon the blood pressure generally. Thus when the brain pressure rises to such a point that the blood stream supplying the medulla is only temporarily interrupted, the vaso-motor centre is stimulated, the blood pressure rises, and the medulla oblongata again receives blood. Therewith, however, the cause of the stimulation ceases and the blood pressure again sinks. If the pressure is of short duration only a single wave of elevation is noticed ; if continuous, a series of waves. Hence an undulating blood pressure curve often results. Bergmann and Duret accept this explanation. The vaso-motor centre in the medulla is held to be readily excitable through anæmic conditions. The effects of anæmia of its substance induced by capillary embolism (lycopodium seeds, injection of oil into the carotid) or ligature of the vessels supplying the brain bear out this assertion.

The actual **state of the vessels** under increased pressure is difficult to observe without in a manner vitiating the experiment. Schultén (No. 92, xxxii. 1885, p. 461) was enabled to form an approximate idea of their condition by relative observations on the ophthalmic. He inserted the cannula of a mercury manometer into the vitreous, and by a special method of illumination noticed the effect of increasing the pressure of the vitreous through the mercury of the U-shaped tube of the manometer.

If the pressure within the vitreous in an animal is below 90, 100, to 120 mm. Hg., the arteries of the retina and choroid show little change. When the pressure comes up to these levels, however, the arterial stream becomes intermittent in the arteries, while that in the veins is unaltered, although they become finer. An addition of from 10-20 mm. Hg. pressure causes the pulsation to cease.

Reasoning by analogy, we may say that in all probability the same influences are exercised upon the vessels of the brain as upon those of the eyeball when the pressure of the cerebro-spinal fluid is raised. This seems all the more likely from the fact that increase of the brain pressure causes narrowing and anæmia of the retinal arteries. Less blood passes through the arteries, owing to the manner in which they are compressed on all sides.

Where the brain over-pressure is slight, **the respiration** becomes irregular; where it rises higher, and where coma has supervened, it is deep and slow; and where it has become still higher, and if the retarded or *vagus pulse* comes on, it is irregular and at times ceases; while, when the vagus paralysis manifests itself by the acceleration of the pulse, the respirations become very laboured and are finally annulled. With weak but continuous pressure there is more irregularity of the breathing than of the pulse, and the breathing becomes affected before the pulse phenomena show themselves.

Loss of consciousness supervenes at a comparatively early period, and if the over-pressure is continued sufficiently long and is so powerful as to call forth the grand phenomena, it sooner or later always proves fatal.

Anomalies in the movements of the pupils are also met with both where the increase of pressure is experimentally induced and where it is the result say of meningitis. In Man a uni- or bi-lateral dilatation of the pupil occurs. Naunyn and Schreiber found it in animals, but there never was any difference in the size on the two sides. When any difference in their size is noticed in Man it may be concluded that it is caused by the local influence of a tumour or inflammatory effusion upon the nerves influencing the size of the pupil.

Chemosis or œdema of the conjunctiva is said by Leyden to be a symptom of meningitis. It may be caused by the elevated brain pressure forcing out an increased quantity of cerebro-spinal fluid into the neighbouring lymphatics. A similar discharge of this fluid takes place from the nose of the dog when its brain pressure is increased. The fluid is at first thick, but afterwards becomes thin and watery.

Amount of Pressure which proves Deleterious.

It may be said that a pressure of 30 mm. Hg. is not free from danger, and that the higher it goes the greater the danger becomes. Quincke found the subarachnoid pressure in a child suffering from acute hydrocephalus, with "choke-disc" eye phenomenon, to range between 30 and 40 mm. Hg. It is reckoned that the grand phenomena ensue whenever the pressure of the cerebro-spinal fluid comes to equal that of the arteries.

All factors which occasion an increase of the cerebro-spinal fluid are liable, *ceteris paribus*, to occasion a rise of brain pressure. Such are hydræmia, and acute inflammatory affections such as meningitis. The pressure may also be the result of hæmorrhage into the basal ganglia or intra-membranous spaces. It is often caused by the presence of tumours.

Actual Cause of the Phenomena.

Almost all the phenomena can be traced ultimately to anæmia of the organ. In the case of tumours, as Adamkiewicz (No. 541 and elsewhere) points out, the direct cause of the pressure and anæmia need not necessarily be the tumour itself, which is sometimes small, but may be the enlargement of the hemisphere, which usually accompanies all brain tumours (see p. 577).

It ought to be remembered that the third ventricle lies immediately above the optic chiasma. The lamina cinerea alone is interposed, and this is so thin that practically the chiasma may be said to constitute the main part of the ventricular floor. In conditions where liquid accumulates in the ventricle, the compression of the chiasma and adjacent parts is so great that the lamina disappears and the chiasma becomes flattened out. The position of parts is such that in the upright state of the body the compression will be greatest. Various anomalies of vision and morbid states of the optic nerve may thus be accounted for.

Indications for Treatment.

Seeing that anæmia is the cause of the phenomena, Naunyn and Schreiber condemn **venesection** as adding to the evil, and extol everything which tends to raise the blood pressure. It is questionable whether this advice is founded upon strictly logical reasoning. Bergmann, on the contrary, recommends venesection on the ground that all increase of pressure within the arteries increases the amount of compression to which the brain is subjected, and so renders still more difficult the already trammelled capillary circulation. The previous authors, however, hold that this is an erroneous argument.

Literature on Brain Pressure.—**v. Bergmann** (Brain Pressure): Arch. f. klin. Chir., xxxii. 1885, p. 705. **Duret**: Études expér. et clin. sur les traumatismes cérebraux, 1878. **Falkenheim and Naunyn** (Brain Pressure): Arch. f. exper. Path. u. Pharmakol., xxii. 1886-87, p. 261. **Jolly**: Untersuchungen üb. d. Gehirndruck, 1871. **Lewy** (Regulation of Circulation in Brain): Arch. f. path. Anat., cxxii. 1890, p. 146. **Leyden** (Brain Pressure and Brain Movement): Arch. f. path. Anat., xxxvii. 1866, p. 519. **Mayer** (Effect of Ligature of Carotids and Blood Pressure): Sitzungsberichte d. k. k. Akad., Wien., lxxiii. iii. p. 85. **Naunyn and Schreiber** (Brain Pressure): Arch. f. exp. Path. u. Pharmakol., xiv. 1881, p. 1. **Pagenstecher**: Experimente u. Studien üb. d. Gehirndruck, 1871. **Rosenbach and Schtscherbak** (Effects of Compression): Arch. f. path. Anat., cxxii. 1890, p. 56. **Schmaus** (Concussion): Arch. f. path. Anat., cxxii. 1890, p. 326. **Spencer and Horsley** (Circulation and Increased Intra-Cranial Pressure): Proc. Roy. Soc. Lond., xlviii. 1890, p. 273.

VARIATIONS IN THE VOLUME OF THE BRAIN.

906. The foregoing observations relate to the effects of increased pressure from the cerebro-spinal fluid upon the brain substance. The experiments of Roy and Sherrington (No. 179, xi. 1890, p. 89) made on dogs were designed to test the effects of different agents upon the volume of the brain itself, quite irrespective of the influence of the cerebro-spinal fluid. Through a trepan hole a recording piston was brought in contact with the cerebral hemisphere, while the cerebro-spinal fluid was allowed to escape at the sides of the aperture. The results, therefore, correspond to the variations of vertical thickness of the cerebral hemisphere irrespective of the influence of the cerebro-spinal liquid. It must be borne in mind consequently that the conditions are not exactly uncomplicated, and that the absence of the incompressible cushion of cerebro-spinal liquid may to a certain extent have modified the effects of the agents applied. Their main conclusions, however, are the following:—

(1) That stimulation by induced currents of the uncut or of the central end of the cut sciatic always produces expansion of the brain. The expansion lasts a varying number of seconds after the stimulus has ceased. The volume of the brain then returns to what it was before the application of the stimulus. Stimulation of any other sensory nerve induces like results. The expansion is probably due to the general rise in arterial pressure caused by the application of the stimulus.

(2) Closure of both carotids causes great shrinking in the volume of the brain from lowering of the blood pressure. Lowering of the arterial pressure from hæmorrhage or other cause has a like effect.

(3) Asphyxia induces active expansion of the cerebral vessels in addition to the passive distension which results from the rise of the arterial and, in certain instances, of the venous pressure.

(4) The blood supply of the brain varies directly with the blood pressure in the systemic arteries.

(5) There is no reason for believing that vaso-motor nerves for the brain are to be found in the nerves of the neck. There is no evidence of their existence outside the cerebro-spinal canal. Nor do they admit that vaso-motor nerves for the brain are to be found in the medulla or in the spinal cord. Direct stimulation of the medulla and cervical cord resulted only in passive arterial congestion.

(6) The regulation of the cerebral circulation is the result of three factors—(*a*) the general arterial pressure of the body; (*b*) the general venous pressure; and (*c*) the presence or absence of chemical products of cerebral metabolism contained in the lymph which bathes the walls of the arterioles of the brain. The last of these, they think, may sometimes act locally on one particular part, bringing about different degrees of cerebral activity.

CHEMICAL REACTION OF THE BRAIN IN RELATION TO VOLUME.

907. Langendorf states that the gray and white parts of the brain are normally alkaline, but that a portion of brain becomes acid even a few minutes after excision. So long as the alkaline blood

is freely supplied to the part the reaction remains alkaline, but as soon as this fails an acid (lactic ?) resulting from the metabolism of the tissue makes its appearance and alters the reaction. The same results follow when the brain is rendered anæmic by ligaturing both carotids, and the acid reaction gradually disappears on reopening the carotids and allowing the blood supply to return.

Roy and Sherrington (No. 179, xi. 1890, p. 98), by introducing comparatively small doses of an acid into a vein, were able to increase the volume of the brain, owing to the expansion of the cerebral vessels thereby induced.

EFFECTS OF INCREASED ATMOSPHERIC PRESSURE ON THE SPINAL CORD.

908. Spinal cord lesions have been reported by Schultze (No. 13, lxxix. 1880, p. 124) and Leyden (see Schultze's paper) as occurring in individuals subjected to sudden variations of atmospheric pressure, as in those working in diving-bells, etc. Schultze, in one case, found distinct degeneration, and what he holds to be indications of myelitis, while Leyden mentions small ruptures of the spinal medulla. The theory is that differences in barometric pressure cause a distension of the blood-vessels of the cord, a condition which acts deleteriously upon the surrounding nervous matter.

CONCUSSION.

909. The beautiful experiments of Duret (No. 542) were perhaps the first to place the pathology of concussion upon a sound basis. Briefly summarised, the results accruing from these experiments may be stated as follows: When a blow is inflicted upon the skull, the bone, which is pliable, becomes momentarily depressed and a wave of cerebro-spinal liquid passes over the brain. Not only does it pass over the surface, but the wave also affects the liquid within the ventricles, whereby it is driven out through the aqueduct of Sylvius and fourth ventricle down upon the spinal cord. The energy of the blow expends itself through the instrumentality of the cerebro-spinal liquid upon the elastic ligaments of the spinal cord. The force with which the liquid is driven downwards stretches the parts injuriously in the neighbourhood of the aqueduct, and small hæmorrhages result. Vascular spasm and anæmia of the brain result, with all the evils attending the latter condition, including temporary loss of consciousness.

In Man, minute hæmorrhages in the above-mentioned situations are among the commonest of occurrences in fatal concussion.

Along with these, punctiform hæmorrhage with laceration of the brain substance is often found at a point of the skull opposite to that of impact. They are the result of what is usually known as *contre-coup*.

GENERAL LITERATURE ON PHYSIOLOGY OF NERVOUS SYSTEM.

Baginsky and Lehmann (Function of Caudate Nucleus): Arch. f. path. Anat., cvi. 1886, p. 258. **Bechterew** (Explanation of Phenomena after Injury of Motor Area): Arch. f. d. ges. Physiol., xxxv. 1884, p. 137; *also* (Function of Cerebellum), Neurol. Centralbl., ix. 1890, p. 354. **Christiani:** Zur Physiologie des Gehirns, 1885. **Darkschewitsch** (Sect. of P. Comm.): Arch. f. d. ges. Physiol., xxxviii. 1885-86, p. 120; *also* (Meaning of Post. Comm.), *Ibid.*, xxxvi. 1885, p. 639. **Davey** (Physiol. Path.): Journ. Psych. Med., Lond., v. 1879, p. 172. **Dees** (Anatomy and Physiology of Vagus): Arch. f. Psychiat., xx. 1888, p. 89. **Exner** (Optic Nerve Zone): Arch. f. d. ges. Physiol., xi. 1875, p. 581. **François-Frank and Pitres** (Excitability of Cereb. Hemispheres): Arch. d. physiol. norm. et path., v. 1885, p. 7 *et seq.* **Gad** (Irritability of Nerves): Arch. f. Physiol., 1889, p. 350; *also* (Relationship of Spinal Nerve Fibres to Ganglion Cells), *Ibid.*, p. 199. **Gaskell** (Nerves which innervate Visceral and Vascular Syst.): Journ. of Physiol., vii. 1886, p. 1. **Gowers** (Function of Cerebellum): Neurol. Centralbl., ix. 1890, p. 194; (Notes on Funct. of Nerv. System) Lancet, 1890, i. pp. 955, 1006, 1113, 1167. **v. Gudden:** Arch. f. Psychiat., ii. 1870, p. 693. **Hällstén** (Sensit. Nerves and Reflexes): Arch. f. Physiol., 1886, p. 92. **Hill** (Relationship of Cerebro-Spinal Gray Masses and Periph. Nerves): Brit. Med. Journ., 1885, i. pp. 530, 586. **Hirschberg** (Stimulation and Conduction): Arch. f. d. ges. Physiol., xxxix. 1886, p. 75. **Hitzig** (Functions of Cerebrum): Biol. Centralbl. vi. 1886-87, p. 562. **Horsley** (P. Cols. of Cord and Cortical Centres): Brain, ix. 1886-87, p. 42. **Horsley and Schaefer** (Stimulation of Motor Tract): Proc. Roy. Soc. Lond., xxxix. 1885, p. 404. **Hürthle** (Innervation of Cerebral Vessels): Arch. f. d. ges. Physiol., xliv. 1888-89, p. 561. **Jackson** (Physiol. and Path.): Brit. Med. Journ., 1884, i. p. 591 *et seq.* **Joseph** (Trophic Nerves): Arch. f. path. Anat., cvii. 1887, p. 119. **Loeb** (Physiol. of Cerebrum): Arch. f. d. ges. Physiol., xxxix. 1886, p. 265. **Mairet** (Nutrition of Nerv. Syst.): Arch. de neurol., ix. 1885, pp. 232, 360. **MacDowall** (Exner's Time of Reaction of Sensorium): Lond. Med. Rec., ii. 1874, p. 30. **Maudsley** (The Double Brain): Mind, xiv. 1889, p. 161. **Mott** (Functions of Corp. Callosum): Brit. Med. Journ., 1890, i. p. 1124; *also* (Cortex and Eye Movements), Brit. Med. Journ., 1890, i. p. 1419. **Mott and Schaefer** (Associated Eye Movements): Brain, xiii. 1890, p. 165; *also* (Movements from Excitation of Corpus Callosum): Brain, xiii. 1890, p. 174. **Ott** (Heat Centres): Brain, xi. 1888-89, p. 433. **Raudnitz** (Thermic Centre): Arch. f. Physiol., 1885, p. 347; *also* (Cortex and Influence on Vessels), Arch. f. Path. Anat., ci. 1885, p. 276. **Reinhard** (Funct. of Corp. Call.): Centralbl. f. Nervenheilk., viii. 1885, p. 73. **Rossolimo** (Physiol. of Fillet): Arch. f. Psychiat., xxi. 1889-90, p. 897. **Schiff** (New Researches on Stimulability of Sp. Cord): Arch. f. d. ges. Physiol., xxxviii. 1885-86, p. 182. **Schräder** (Comp. Physiol. of Cerebrum): Deut. med. Wochnschr., xvi. 1890, p. 307. **Seguin:** N. Y. Med. Rec., 1874, ix. p. 617. **Sharkey** (Spasm): Brit. Med. Journ., 1886, i. p. 531. **Starr** (Sensory Tract): Journ. Nerv. and Ment. Dis., 1884, ix. p. 327. **Unverricht** (Double Crossing of Nerve Tracts): Neurol. Centralbl., ix. 1890, pp. 483, 524. **Westphal** (Symptom Complex in Disease of P. Cols.): Arch. f. Psychiat., xvi. 1885, p. 496 *et seq.* **White** (Corp. Striat. and Opt. Thal. in Relation to Bodily Temperature): Journ. of Physiol., xi. 1890, p. 1. **Ziehen** (Physiol. of Infracortical Ganglia): Arch. f. Psychiat., xxi. 1889-90, p. 863.

CHAPTER LXXIX

THE NERVOUS SYSTEM—(*Continued*)

ANÆMIA AND HYPERÆMIA OF THE CENTRAL NERVOUS SYSTEM.

910. **Definition.**—By cerebral anæmia is commonly understood *a condition in which the amount of blood passing through the organ is lessened.*

The encephalic cavity being filled and its contents practically incompressible, it is evident that anæmia and hyperæmia of the brain must of necessity be dependent upon a disturbance in the balance struck by the blood pressure on the one hand and the pressure of the cerebro-spinal liquid on the other.

Appearances of anæmia and congestion found after death must always be interpreted with care. In illustration of the necessity for this the condition of the brain in *convulsions* may be cited. Thus if the individual die during a powerful convulsion the brain may be found blanched; while if death supervene some time after the convulsive attack is over, a state of extreme hyperæmia is just as likely to be met with. To reason as to the state of the brain in convulsions from either of these data alone would accordingly be misleading.

The phenomena of disturbed cerebral circulation being vital, they must in great part be studied by experimental methods. Several of the most important results bearing on the subject, and obtained by this means, will be found under *Brain Pressure* (Sect. 905).

Local anæmia is usually the result of mechanical obstruction. Its effects are discussed under *Cerebral Embolism.* There is a possibility that spasm of a single vessel may prevail to such a degree as to cause a complete obstruction. Cases of aphasia without evident lesion seem explicable alone on this basis (see *Aphasia*).

APOPLEXY.

(ἀποπληξία, from ἀποπλήσσομαι, *to strike with amazement.*)

911. **Definition.**—The term is employed in two senses: (1) either as indicative of *a hæmorrhage into the brain or spinal cord*; or (2) as

referring to *the symptoms which follow upon such a hæmorrhage.* In the sense merely of a hæmorrhage the term is often applied to an effusion of blood not merely into the central nervous system, but into other organs like the lung or spleen. At present the term will be used simply in the sense of indicating a hæmorrhage without reference to the symptoms induced by it.

Varieties and General Causes.

The effused blood may be found in the following situations:—

(1) Between the dura mater and the bone.
(2) In the subdural space.
(3) In the subarachnoid space.
(4) In the brain itself.
(5) In the ventricles and central canal.

In any of the first three varieties the cause is usually traumatic; the latter two may be traumatic, but are more frequently caused by rupture of a vessel from disease of its coats.

It must be remembered, however, that a hæmorrhage, say into the ventricles, and primarily due to disease of the vessels, may rupture through the brain substance, and find its way into the subarachnoid, or even into the subdural space.

The commonest cause of traumatic hæmorrhage is laceration of a meningeal artery, more particularly of the middle meningeal, associated with a fracture of the base of the skull. The blood is usually poured into the subdural space, and lies oftenest over the motor area of the cerebral hemisphere. It is often circumscribed in a saucer-shaped mass exactly over the fissure of Rolando and its vicinity. The blood does not tend to diffuse, probably owing to there being little if any liquid between the dura and arachnoid. When the hæmorrhage takes place beneath the arachnoid, from traumatic causes, it is as a rule associated with laceration of the neighbouring brain substance. The actual injury is caused mostly by *contre-coup.*

Punctiform hæmorrhages into the pia are seen in so-called blood disease, such as pernicious anæmia, purpura, typhoid, etc.

Cerebral hæmorrhage, as above mentioned, is usually a result of disease of the vessels—atheroma, miliary aneurism, simple fatty degeneration. The commonest site is undoubtedly the basal ganglia. It will be remembered that the basal ganglia are supplied by the perforating branches given off from the main stems of the circle of Willis (Sect. 903). Those derived from the middle cerebral are most commonly implicated in basal ganglion hæmorrhage. They are of two orders, external and internal. *The external* are the larger, and there is always one of considerable size which runs along the base of the lenticular nucleus. If the parts lying external to the lenticular nucleus are carefully removed this artery is exposed. It is known as the **lenticulo-striate artery**, and its branches of distribution supply the anterior two-thirds of the outer segment of the lenticular nucleus. The other external branches are distributed to the posterior extremity of the lenticular nucleus. They are known as the **lenticulo-optic.** *The internal* perforating branches supply the inner and middle segments of the lenticular nucleus, and are named the **lenticular arteries.**

It is from these various branches, and, according to Charcot (No. 543, p. 80), from the lenticulo-striate artery in particular, that the blood issues in basal ganglion hæmorrhage. From the fact that they lie deeply, the blood tends to lacerate the important parts in the neighbourhood. Hence the serious, it may almost be said irremediable, nature of the injury, for although, possibly, more or less complete recovery might take place were the gray matter alone destroyed, yet the fact of the inner capsule lying so close to the gray masses renders its injury almost certain when the hæmorrhage is at all extensive, and the damage consequently irreparable.

The blood, having torn up the basal masses of gray matter, tends to make its way into the lateral ventricle, and, if copious, not only may it be poured into one lateral ventricle, but the entire ventricular system, down even as far as the fourth ventricle, may be filled to distension. In all such copious hæmorrhages, either into the ventricles or between the membranes, the brain is peculiarly anæmic. This does not appear to be a *post-mortem* appearance; it is evidently due to the pressure exerted by the mass of effused blood upon the intracranial vessels. The deep coma which follows upon such a copious hæmorrhage still further bears out the supposition that the vessels are in a state of anæmia from compression.

It ought to be remembered, however, as Schultén (No. 96, xxxii. 1885, p. 742) remarks, that as a matter of fact no case of "choke-disc," a condition so often associated with intracranial over-pressure, has been recorded in connection with depression of the skull or extravasation of blood between the dura and bone. The same holds good of localised hæmorrhages. The retinal circulation is little affected in ordinary cerebral apoplexy. Should the blood, however, be poured into the subdural or subarachnoid space, especially at the base, blood and serum find their way into the sheath of the optic nerve and compress the vessels; "choke-disc" under such circumstances may be detected.

Hæmorrhage into the cerebellum is peculiarly fatal. The individual affected by it seldom lives more than six hours, probably from the pressure exerted by the swollen hemisphere upon the fourth ventricle. It may occur in young people, particularly in young women, and is due to a simple fatty degeneration of the small arteries and their capillaries.

Spurious Apoplexy.—It is worthy of note, however, that a person may die with all the signs and symptoms of a massive intracranial hæmorrhage without a particle of blood having been effused. There are several such cases on record (*e.g.* Ross, No. 521, ix. 1887, p. 41), and curiously there is sometimes nothing to account for the fatal issue.

Hæmorrhage into the medulla oblongata or pons is usually rapidly fatal, from interference with the important centres in their locality.

Hæmorrhage into the spinal cord seldom takes place in mass as a result of disease. Small hæmorrhages, however, occur in cases where there is hyperæmia. They lie mostly in the vicinity of the primary divisions of the arteries of the anterior fissure. The spinal arteries do not often become atheromatous, hence perhaps the fact of spinal apoplexy being rare. As a result of injury, such as fracture of the spine and so forth, apoplexies of the cord are often met with. Whether concussion of the spine can occasion them may be doubted.

Changes in the Part after the Blood is effused.

The blood when effused in a massive hæmorrhage appears to coagulate rapidly, and when cut into is seen lying in the lacerated brain substance in the form of a black mass. Round about it there may be some minor punctiform hæmorrhages, and some of the blood-colouring matter may be seen exuding into and discolouring the neighbouring pia mater.

Floated in water, the *miliary aneurism*, which has probably been the cause of the extravasation, will come into view. These aneurisms are sometimes very numerous and scattered through the brain substance. A larger aneurism is seen occasionally on the vessels at the base of the brain.

As in other localities, the blood soon begins to be absorbed, and the process of repair sets in. The serum is first of all removed from the clot, and the surrounding tissues become stained with it while this is going on. The broken-down tissues mixed with the remains of the clot now constitute a brown chocolate-like mass, which is more or less encapsuled. The wall of the capsule becomes fibrous later on, and the remains of the blood are entirely got rid of, with the exception of quantities of hæmatoidin either in a crystalline or granular form. This pigment gives to the interior of these cavities an orange-yellow colour, which is particularly diagnostic. The cavity becomes filled with more or less serum-like fluid as the blood mass is removed. Sometimes these cystic cavities continue for the remainder of the patient's life; at other times the vacuity cicatrises and contracts. The reparative process, ending in the formation of the cyst-like structure, usually sets in about the end of the first week; the cyst is circumscribed by about the twentieth day; and the lining membrane is thoroughly organised by from the thirtieth to the fortieth day.

Hæmatoma of Dura Mater.

912. Syn.—*Pachymeningitis hæmorrhagica interna; Néomembranes de l'arachnoide.*

These terms are applied to a lesion whose pathology was and still is in some doubt. It consists in the development between the dura mater and arachnoid, that is to say, in the subdural space, of a thin membranous cyst containing remains of blood. The cyst is usually very large, may cover an entire cerebral hemisphere, and is applied flatly to the cerebral surface. The wall, in typical cases, is almost as thin as the arachnoid itself, and forms either a single sac or one which is imperfectly multilocular. The cyst is loosely adherent to the interior of the dura mater and to the arachnoid, but the adhesions are such as to allow of its being readily stripped off. Blood-vessels pass from the dura mater into those of the cyst-wall, and as showing the continuity of their channels, blood can be squeezed with the finger

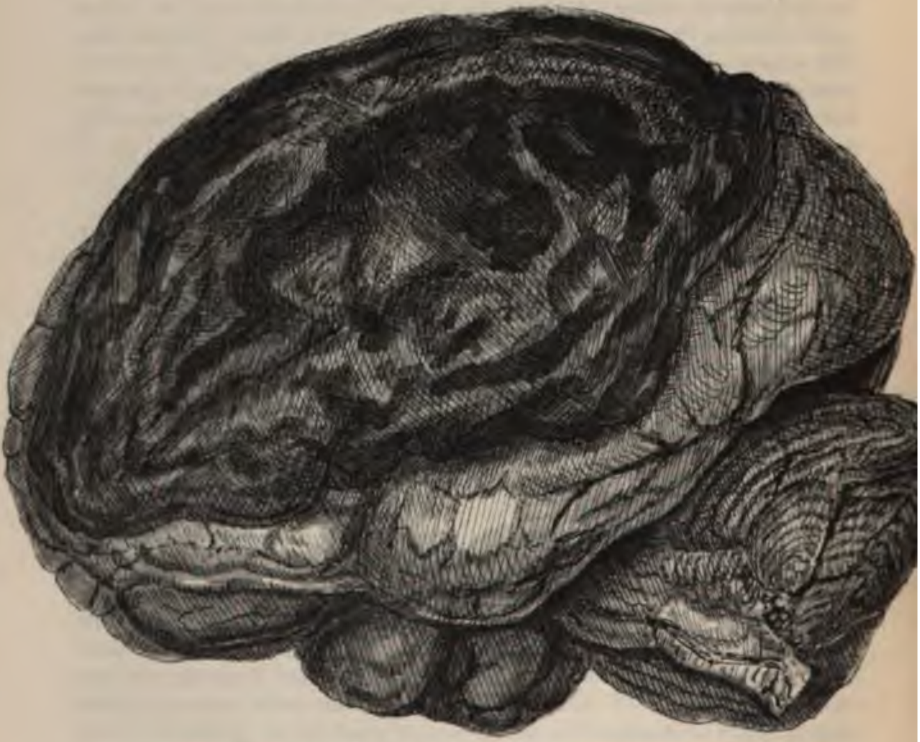


FIG. 423.—HÆMATOMA OF DURA MATER SHOWING THE CYST LYING OVER SURFACE OF BRAIN.

from the one into the other. The membranous sac, when small, lies along the middle meningeal artery, whose channel is often wide. Small deposits of lime salts are occasionally found in the wall.

The contents, as a rule, are thick brown-coloured liquid containing numerous cells, of round, oval, or spindle shape, often arranged in groups, with, in recent cases, the remains of blood-corpuscles. The nuclei of these cells are prominent; they are often from two to four in number. The contents have been found by Ormerod (No. 192, xxxviii. 1887, p. 13) to be gelatinous at one part, hæmorrhagic at another. In many cases the dura is quite unchanged, but, rarely, the cyst is continuously adherent to its internal surface. In such cases it is of irregular form, while its wall is thicker and coarser in texture and is laminated. *The brain* presents a saucer-like depression where the cyst has pressed upon it, which does not vanish on removal of the organ from the skull. The brain otherwise may appear to be healthy.

The disease is of very common occurrence in asylums for the insane, to which probably the subjects of the disease gravitate, on account of the symptoms from which they suffer. It has been found oftener in *General Paralysis of the Insane* than in any other variety of mental ailment. Indeed, Wiglesworth says it is commoner in General Paralysis of the Insane than in all other forms of insanity put together. Out of four hundred unselected autopsies in Rainhill Asylum he found forty-two, or 10·5 per cent, in which the subdural space contained blood, membrane, or both.

It is a disease mostly of **adult life,** but may present itself in children. Wiglesworth found the average age in Asylum patients to be 51·07 years.

The symptoms vary so much and come on, as a rule, so insidiously that there are few features whereby the presence of the cyst can be established. Stewart found *double optic neuritis* even when the sac covered the left hemisphere only.

Nature of the Disease.—Every one admits that hæmorrhage plays an important *rôle* in the disease, but where the blood comes from, and whether the hæmorrhage is primary or is secondary to a pachymeningitis, have long been disputed points.

Thus Virchow and Heschl (No. 119, vii. 1856) were of opinion that the hæmorrhage is secondary to the formation of membranes; that, in fact, the disease is essentially a *hæmorrhagic pachymeningitis.*

Kremiansky (No. 13, xlii. 1868, p. 129), as a result of extensive observation, took the view that the membranes may be formed before or after the hæmorrhage, but that in all cases they are of inflammatory origin.

Clouston (No. 544) and Wiglesworth (No. 526, Jan. 1888, *also* Reprint), on the other hand, both discard the idea of the condition being primarily of an inflammatory nature. Wiglesworth holds that the disease commences as a hæmorrhage, and that the blood becomes organised and converted into membranes.

With this view the author coincides, without denying that a hæmorrhage may result from a pachymeningitis and diffuse itself in the subdural space. In a case which lately came under his notice he was enabled to trace the very commencement of the disease. A thin film of blood with sharply-defined borders lay over an entire cerebral hemisphere in the subdural space. The blood was firmly coagulated, so that it could be stripped off in a continuous layer. There was no traumatism to account for it, nor could the source of the hæmorrhage be detected. It looked as if the blood had oozed out from a neighbouring vein. The blood is evidently not absorbed, but in course of time becomes encapsuled with fibrous tissue. The membranes in this case appeared to be quite healthy.

In the Cord.—Similar membranes are occasionally present in the spinal canal. They are generally less hæmorrhagic and more fibrinous than those within the skull (see Wiglesworth and Smith, No. 6, 1889, ii. pp. 644, 645).

Literature on Hæmatoma of Dura Mater.—**Dercum and Morey:** Univ. M. Mag., Phila., 1889-90, ii. p. 509. **Discussion on Fibrinous Membranes within Sp. Canal in Gen. Paralysis:** Brit. Med. Journ., 1889, ii. p. 644. **Dixon:** N. Y. Med. Rec., xxvi. 1884, p. 670. **Kremiansky:** Arch. f. path. Anat., xlii. 1868, p. 129. **Goodall:** Journ. Ment. Sc., xxxviii. 1892, p. 397. **Ogle** (Formation of False Membranes): Arch. Med. Lond., i. 1857-59, p. 270; ii. 1860-61, p. 85. **Ormerod:** Trans. Path. Soc. Lond., xxxviii. 1887, p. 13. **Sainsbury** (Hæmatoma of Dura Mater): Trans. Path. Soc. Lond., xxxviii. 1887, p. 12. **Schuberg:** Arch. f. path. Anat., xvi. 1859, p. 464; *Ibid.*, xx. 1861, p. 301. **Turner:** Trans. Path. Soc. Lond., xxxvi. 1884-85, p. 16. **Virchow:** Verhandl. d. med.-physic. Gesellsch. zu Würzburg, vii. 1856. **Wiglesworth** (Prize Essay): Journ. Ment. Science, Jan. 1888; *also*, Reprint; *also*, Americ. Journ. of Insanity, Jan. 1891. **Wythe:** Am. Lancet, x. 1886, p. 363.

ENCEPHALIC EMBOLISM.

913. The general features of cerebral embolism have already been given in Section 600. It now remains to describe these in further detail.

Nature of Embolus.—It is usually a vegetation or clot detached from the heart, or, it may be, a calcareous scale from the aorta. The middle cerebral, from its immediate connection with the internal carotid, is the vessel in which it most often catches, but it may be found occasionally in the other primary branches of the circle of Willis. The effect produced depends accordingly upon the distribution of the respective vessels. The left middle cerebral is oftener embolic than the right, owing, it is said, to the left carotid coming off more directly from the aorta than the right.

Site and Effect on Vessel.—The embolus usually catches in the middle cerebral either before or shortly after it diverges into the Sylvian fossa; the exact point corresponds to the bulk of the foreign body. It becomes firmly impacted within the artery, and by subsequent clotting of the blood around it the occlusion of the vessel is rendered complete. The thrombus thus precipitated round the embolus may extend for some distance at the distal end. Later on, both the thrombus and embolus are absorbed, and *pari passu* with their removal the inner coat thickens and encroaches upon the lumen of the vessel to such an extent that in course of time a complete occlusion follows. When once thoroughly plugged, the artery never seems to regain its patency. The appearance presented by an artery a few months after having been the subject of embolic impact is practically identical with that of a vessel the subject of arteriitis obliterans; the condition is sometimes mistaken for syphilitic.

Effect on Brain.—It is generally recognised that, after impaction, the part supplied by the occluded vessel becomes *pale and anæmic.* The cause of this probably is that the *vis a tergo* of the circulating blood is for the time being withdrawn. Should the affected area be irrigated by vessels which anastomose with those around, the blood probably returns shortly after the natural supply is withdrawn. If, however, it is traversed by vessels which are terminal, as in the case of the basal ganglia and inner capsule, the blood remaining in the vessels may be pressed out by the collateral distension which occurs in arteries still pervious. Geigel (No. 13, cxxi. 1890, p. 432) considers that the anæmia thus induced is the cause of the *embolic shock*, the more or less complete loss of consciousness, and the other signs of disturbance of nutrition.

A coagulative necrosis usually sets in within a day or two. The vessels in the vicinity of the resulting infarction are engorged with blood, and should there be an attempt at anastomotic restoration of the interrupted blood-current, the anæmic capillaries may give way when the blood returns to them, and punctiform hæmorrhages follow thereupon. Blood-colouring matter oozes out from these and other sources and stains the embolised area, with the effect that it assumes a pink or rusty colour. Fatty degeneration sets in before long, so that the infarct becomes soft. The term *red softening* used to be applied to the condition of the implicated portion of brain substance.

The blood-colouring matter being in course of time absorbed or decomposed into hæmatoidin, the infarct assumes a yellow colour and gives rise to an appearance formerly described as *yellow softening.* Within it are found multitudes of compound granular corpuscles.

Absorption follows next, and as it progresses, the affected area, which previously was somewhat protuberant, now sinks below the level of the surface. If situated on the convexity of a hemisphere the pia-arachnoid is drawn inwards and forms a species of cicatrix. A *porencephalous condition* (see p. 581) sometimes results from the connections which this membrane forms with neighbouring parts.

The amount of destruction effected by a cerebral embolus depends upon the distribution of the affected vessel and the fact of its being terminal or not. As before explained, the superficial or cortical branches of the cerebrum have a pretty free anastomosis; while the deep or perforating branches, those passing up to the basal ganglia, are completely terminal. It often happens that, notwithstanding the anastomosis of its vessels, the cortex gives way and dies; while, on the other hand, in some instances of embolic occlusion of the middle cerebral at or near its origin, important as that vessel is for the supply of the cortex, the gray matter maintains its vitality, while the deeper parts supplied by its perforating branches suffer more or less complete absorption.

Areas of Distribution of Encephalic Blood-Vessels.—The following, taken from Duret (No. 4, 1874, i. p. 60), will serve as a guide to the area of distribution of the different branches of the circle of Willis, and, accordingly, to the amount of destruction that may be expected to follow their occlusion :—

I.—Anterior Communicating.

(*a*) Small branches to the gray lamina of the optic chiasma.
(*b*) Anterioles which penetrate the beak of the corpus callosum.
(*c*) Very often deep branches which supply the olfactory trigone, anterior commissure, and septum lucidum.

II.—Anterior Cerebral.

(Within the circle of Willis.)

(*a*) Internal arteries of the optic nerve on the corresponding side.
(*b*) External arteries to neighbouring convolutions and to beak of corpus callosum.
(*c*) Arteries to caudate nucleus (not constant). They plunge deeply into the cerebral substance internal to the olfactory tract, and penetrating the corpus callosum below, divide into five or six branches, which are supplied to the anterior two centimètres of the caudate nucleus.

(Outside the circle of Willis.)

(*d*) Passes up the great longitudinal fissure and divides into three terminal branches distributed to the parts on the side of the fissure, namely, part of the third frontal convolution, the gyrus rectus and olfactory trigone out to the sulcus orbitalis, the gyrus fornicatus, corpus callosum and internal face of the first frontal and the paracentral lobule, and ends at the superior parietal lobule.

III.—Internal Carotid.

(*a*) Small branches to the chiasma externally.
(*b*) Sometimes one or two small twigs to the anterior perforated space for the supply of the head of the caudate nucleus.
(*c*) Anterior choroideal artery which, passing backwards, accompanies the optic tract and enters the choroid plexus through the cornu Ammonis. It gives branches to the optic tract, cerebral peduncle, and unciform gyrus.

IV.—Posterior Communicating.

(*a*) Branches to posterior part of optic chiasma.
(*b*) Branches to tuber cinereum and pituitary body.
(*c*) The arteries of the mammillary bodies.
(*d*) Often two branches to the optic thalamus.

V.—Posterior Cerebral.

(*a*) Branches to pons Varolii given off at the bifurcation of the basilar.
(*b*) Three or four small arteries for the inner aspect of the crura cerebri.
(*c*) Small branches which enter the posterior perforated space, and ascending supply the optic thalamus.
(*d*) Almost all the arteries of the ventricular walls.
(*e*) Branches to the gyrus angularis, and lower aspect of temporo-sphenoidal lobe and the occipital lobe.
(*f*) Branches to the following more or less internal parts: Optic thalamus (posteriorly), cerebral peduncles, corpora quadrigemina, corpora geniculata, choroid plexus (posteriorly), cornu Ammonis.
(*g*) Interpeduncular perforating branches. They pass into the posterior perforated space, and ascending supply blood to the locus niger.

VI.—Middle Cerebral.

(*a*) Perforating branches which ascend to the basal ganglia. They are divided into two sets—external and internal.
The external is the larger, and its branches ramify in the outer segment of the lenticular nucleus. Among them is a particularly large group, the *lenticulo-striate*, comprising four or five branches which pass backwards. Farther back there is another group distributed to the posterior extremity of the lenticular nucleus, and known as the *lenticulo-optic.*
The internal ramify within the inner and middle segments of the lenticular nucleus.
(*b*) Branches to the claustrum which perforate the island of Reil. The claustrum is nourished by these vessels alone, and is detached, as regards its circulation, from the rest of the basal ganglia.
(*c*) Small branches to the nucleus amygdalaris.

The Sylvian artery or continuation of the middle cerebral divides into four branches. *The first* goes to the third frontal convolution; *the second* to the second frontal; *the third* to the ascending frontal and ascending parietal, and often to a part of the superior parietal lobule; and *the fourth*, which is more voluminous, supplies the inferior parietal lobule, but does not pass the interparietal fissure, and the first temporal convolution.

The Supply of the Cerebral Cortex.—There are two sets of arteries, one long set passing through the gray matter into the white, another ramifying exclusively in the gray matter. The former is known as the medullary set, the latter as the cortical. The cortical network has the following distribution. Quite on the surface there exists a quadrangular capillary mesh-work. The meshes are large and lie parallel with the surface. The subjacent two millimètres are filled with fine polygonal capillary meshes, which correspond with the large cortical cells. The deepest millimètre of the cortex contains wider meshes.

The veins do not accompany the arteries; they are medullary and cortical, like the arteries. It has been alleged that there is a direct anastomosis of veins and arteries in the pia mater, but the fact is doubtful.

The arterial supply of the cerebellum is effected through branches given off from the vertebral and basilar arteries. Inferior cerebellar branches are derived from each of these, while the basilar also gives off an anterior cerebellar branch. In front, the basilar breaks up into the two superior cerebellar and the two posterior cerebral arteries, with the third nerve between them. It is very rarely that any of these are occluded by an embolus. They often enough suffer from syphilitic obliteration.

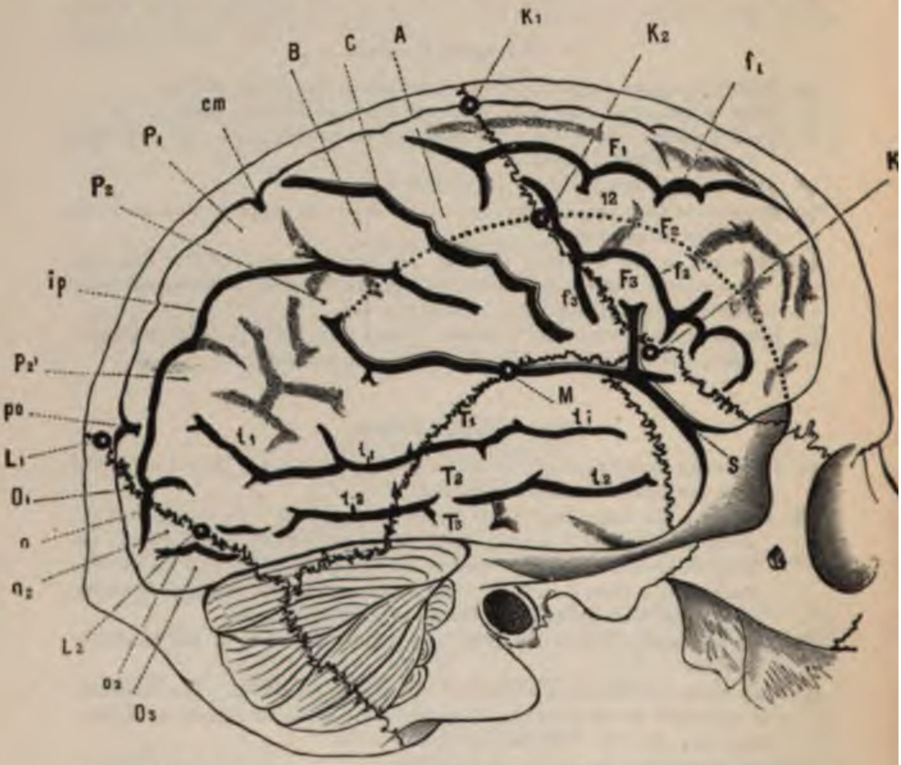


FIG. 424.—THE SKULL LAID OPEN TO SHOW THE PHYSIOLOGICAL TOPOGRAPHY OF THE CONVOLUTIONS (after Ecker).

(S) Sylvian fissure, with its short ascending ramus and its posterior long horizontal ramus; (C) central sulcus or fissure of Rolando; (A) anterior and (B) posterior central convolutions; (F_1) upper, (F_2) middle, and (F_3) lowest frontal convolution; (f_1) superior and (f_2) inferior frontal sulci; (f_3) sulcus præcentralis; (P_1) superior, (P_2) inferior parietal lobule, with fig. P_2 pointing to gyrus supra-marginalis; (P_2') gyrus angularis; (*ip*) sulcus interparietalis; (*cm*) end of calloso-marginal fissure; (O_1, O_2, O_3) occipital convolutions; (*po*) parieto-occipital fissure; (T_1, T_2, T_3) temporo-sphenoidal convolutions; (t_1, t_2) first and second temporo-sphenoidal sulci; (K_1, K_2, K_3) points in the coronal suture; (L_1, L_2) in the lambdoidal suture; (M) in the squamosal suture.

CRANIAL TOPOGRAPHY.

914. It would be out of place in a work on Pathology to discuss the various systems that have been adopted for localising the position of the convolutions, fissures, etc., on the cranial vault. The reader is referred for detailed information on this subject to the works of Turner (No. 5, viii. 1874, pp. 142 and 359), Lucas-Championnière (No. 545), Hare (No. 5, xviii. 1884, p. 174), and Reid (59, 1884, ii. p. 539).

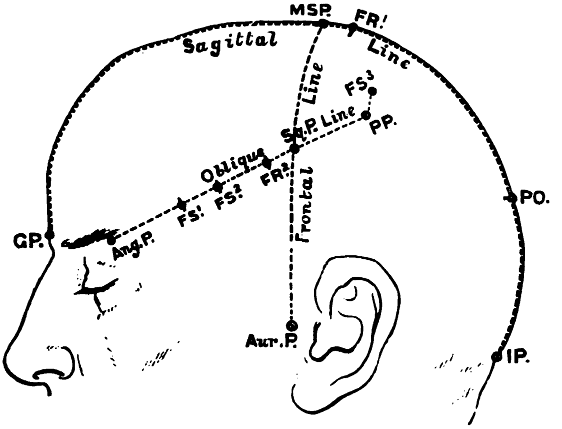


FIG. 425.—CRANIO-CEREBRAL GUIDING LINES, TRACED UPON A CAST OF PROFESSOR CUNNINGHAM'S (from a photograph).

(GP) Glabellar point, glabella opposite superior border of orbit; (IP) initial point, at external occipital protuberance: (MSP) 'mid-sagittal point, midway between GP and IP; (Ang.P) angular point, external angular process opposite upper border of orbit; (Sq.P) squamosal point, intersection of squamosal and frontal lines at junction of middle and lower thirds of latter; (PP) parietal point, termination of squamosal line, equidistant with FS^2 from squamosal point; (Aur.P) pre-auricular point, depression in front of tragus, at level of upper border of external auditory meatus; (FS^1) "commencement" of fissure of Sylvius, $\frac{6}{12}$ of distance from Ang.P to Sq.P; (FS^2) bifurcation of fissure of Sylvius, $\frac{7}{12}$ of distance from Ang.P to Sq.P; (FS^3) termination of fissure of Sylvius, ¾ an inch above PP, in a direction parallel to frontal line; (FR^1) upper extremity of fissure of Rolando carried to sagittal line in direction of fissure, ⅝ of an inch behind mid-sagittal point; (FR^2) lower extremity of fissure of Rolando carried to squamosal line in direction of fissure, ⅝ of an inch in front of squamosal point; (PO) external parieto-occipital fissure, carried to sagittal line in direction of fissure, $\frac{7}{12}$ of distance from MSP to IP. (Anderson and Makins.)

The sutures of the skull are not of sufficiently fixed position to enable them to be utilised as guides to the minor subdivisions of the cortex. Anderson and Makins (No. 5, xxiii. 1889, p. 455), after a very careful inquiry into the matter, found, for instance, that the summit of the parietal eminence has a range of variation in position half an inch in the vertical and an inch in the horizontal direction, after correction had been made for the varying dimensions of skulls; the distance of the bregma from the glabella has a corrected range of variation of a little over half an inch; the distance of the apex of the lambdoid suture from the external occipital protuberance varies to the extent of seven-eighths of an inch; while the positions of the squamous suture, the temporal ridge, and the spheno-parietal suture are equally uncertain. The position and form of the sulci and convolutions even vary on the two sides of the body.

The eminences most easily defined through the scalp are the glabella, the external angular process, and the external occipital protuberance; and although these, like the rest, are subject to irregularities of position, yet the variations are too small to interfere seriously with their value as surgical landmarks. Starting with these as fixed points, the above authors have devised certain "guiding lines" as aids to localisation. These are, firstly, the **Sagittal line**, extending mesially from the glabella at a point midway between the highest points of the supra-orbital arches to the external occipital protuberance; secondly, the **Frontal line**, running from the mid-point of the sagittal line to the depression immediately in front of the tragus, at the level of the upper border of the meatus; thirdly, the **Squamosal line**, passing from the most prominent point of the external angular process, at the level of the superior border of the orbit to the junction of the middle and lower thirds of the frontal line, and prolonged for about an inch and a half behind this. The points corresponding to their extremities they designate *glabellar*, *mid-sagittal*, *inial*, *pre-auricular*, *angular*, *squamosal*, and *parietal* (see Fig. 425).

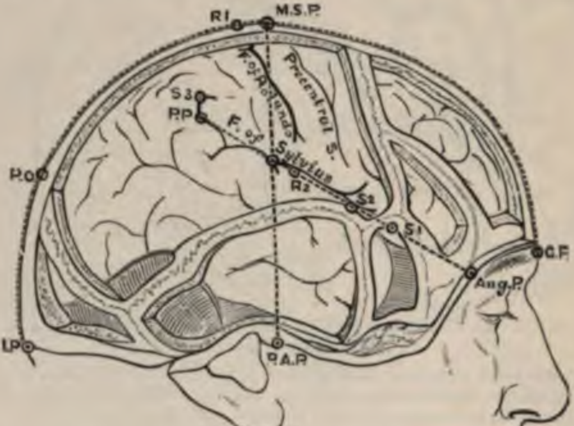


Fig. 426.—Outline traced from a Photograph of a Cast of Professor Cunningham's. (For references, see Fig. 425.)

(1) The *upper extremity* of the fissure of Rolando was found to lie in all cases between the mid-sagittal point and a point three-quarters of an inch behind it. The centre of the trephine, they say, should lie three-eighths of an inch behind the mid-sagittal point.

(2) The *lower extremity* of the sulcus is located in the squamosal line between the junction of this line with the frontal line (squamosal point) and three-fourths of an inch in front of this. The centre of the trephine may be applied three-eighths of an inch in front of the squamosal point.

(3) The commencement of the fissure of Sylvius, being a somewhat indefinite locality, cannot be localised with much exactitude, but will usually be hit at a point from 1½ to 2 inches behind the external angular process. The course of the horizontal limb of the fissure corresponds closely to the squamosal line.

(4) The external parieto-occipital fissure joins the great longitudinal fissure at a

point averaging $\frac{7}{12}$ of the distance measured from the mid-sagittal point to the external occipital protuberance, and lies near to the apex of the lambdoid suture.

The longitudinal sinus, it should be remembered, frequently deviates towards the right side in the posterior half of its course.

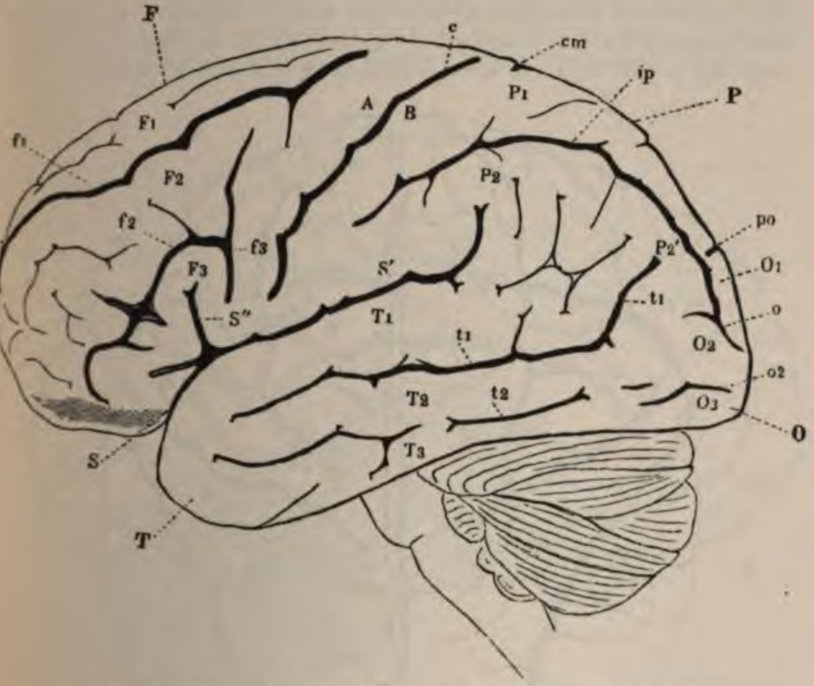


FIG. 427.—LEFT SIDE OF THE HUMAN BRAIN, PARTLY DIAGRAMMATIC (after Ecker).

(F) Frontal lobe; (P) parietal lobe; (O) occipital lobe; (T) temporo-sphenoidal lobe; (S) fissure of Sylvius; (S') horizontal; (S″) ascending ramus of S; (c) sulcus centralis, or fissure of Rolando; (A) ascending frontal, and (B) ascending parietal convolution; (F_1) superior, (F_2) middle, and (F_3) inferior frontal convolutions; (f_1) superior, and (f_2) inferior frontal fissures; (f_3) sulcus præcentralis; (P_1) superior parietal lobule; (P_2) inferior parietal lobule, consisting of (P_2) supra-marginal gyrus, and (P'_2) angular gyrus; (*ip*) sulcus interparietalis; (*cm*) termination of calloso-marginal fissure; (O_1) first, (O_2) second, (O_3) third occipital convolutions; (*po*) parieto-occipital fissure; (o_1) transverse occipital fissure; (o_2) inferior longitudinal occipital fissure; (T_1) first, (T_2) second, (T_3) third temporo-sphenoidal convolutions; (t_1) first, (t_2) second temporo-sphenoidal sulci.

LESIONS OF THE CEREBRAL CORTEX.

The Convolutions.

915. The accompanying schemes (Figs. 427 and 428) will probably be sufficient to remind the reader of the position and nomenclature of the various fissures and convolutions on the surface of the cerebrum. The nomenclature is that usually adopted in this country, and is founded chiefly on the works of Gratiolet, Owen, Turner, Ecker, etc.

The Motor Centres.

916. It is impossible, unless in a special monograph, to treat of this subject satisfactorily from the historical point of view. All that will at present be attempted is to give a brief summary of what is known about the motor centres in the brain of the monkey, afterwards showing in how far these are represented in the brain of Man.

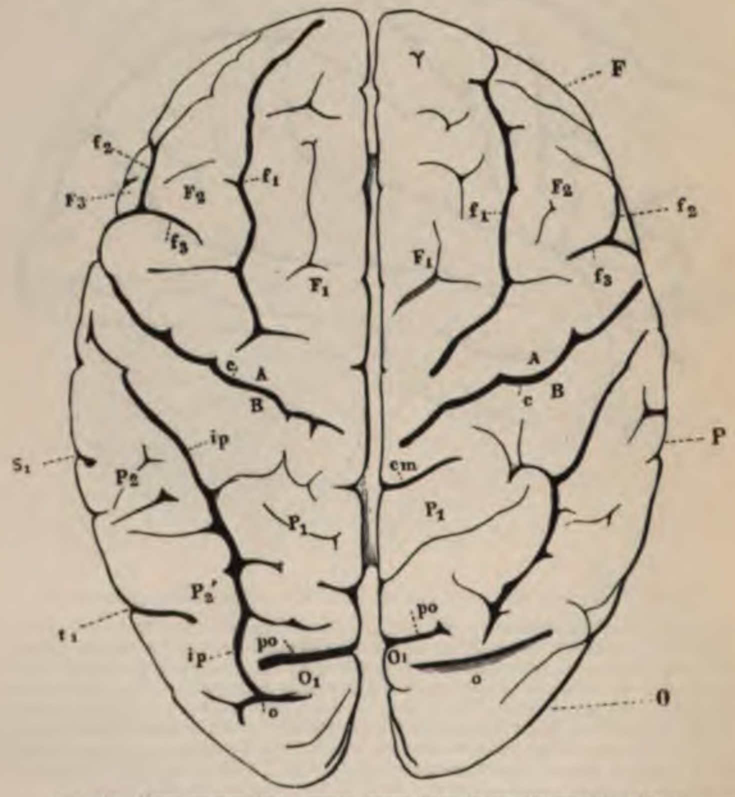


FIG. 428.—VIEW OF THE BRAIN FROM ABOVE, SEMI-DIAGRAMMATIC (after Ecker).
(S_1) End of ramus of the Sylvian fissure. The other letters refer to the same parts as in Fig. 427.

Cortical Motor Centres in the Brain of the Monkey.[1]

917. The pre-frontal lobe—that is, all the brain in advance of a line drawn at right angles to the anterior extremity of the pre-central sulcus—gives no, or very doubtful, response to electrical stimulation.

---

[1] The statements made in this summary are partly taken from Ferrier's *Croonian Lectures* (No. 59, 1890, i. p. 1287).

Between this line and that of the pre-central sulcus continued upwards to the longitudinal fissure there is a region or area (Fig. 430, 12) stimulation of which causes opening of the eyes, dilatation of the pupils, and movements of the head and eyes to the opposite side. Beevor and Horsley further differentiate this area as shown in Fig. 433. This centre is found in the dog, but does not seem to exist in the cat or rabbit. It is questionable whether it prevails in Man.

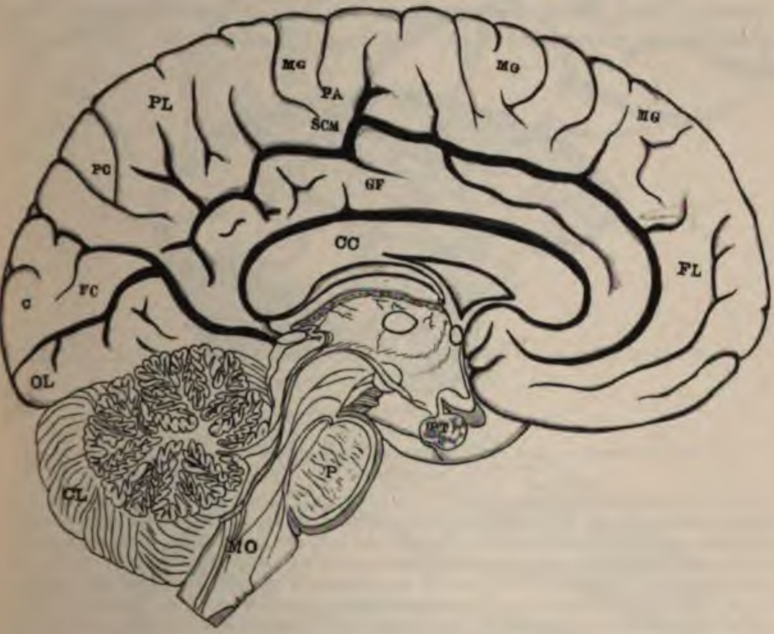


FIG. 429.—VIEW OF THE MESIAL ASPECT OF THE BRAIN (modified from Richet).

(FL) Frontal lobe; (PL) parietal lobe; (OL) occipital lobe; (CL) cerebellum; (CC) corpus callosum; (P) pons; (MO) medulla oblongata; (MG, MG, MG) marginal gyrus; (SCM) sulcus calloso-marginalis; (FC) fissura calcarina; (C) cuneus; (PC) precuneus; (GF) gyrus fornicatus; (PT) pituitary body.

The upper extremities of the ascending frontal and ascending parietal convolutions, the postero-parietal lobule, and the neighbouring part of the surface extending over the margin of the hemisphere into the posterior part of the marginal convolution or para-central lobule (Fig. 430, 1, 2; and Figs. 431 and 432, "Leg") is a centre for movements of the lower extremity. Behind the fissure of Rolando the movements are mainly of the foot or toes. Anterior to the fissure of Rolando they are combined with flexion of the leg and thigh. The great toe can be excited to flexion separately from the others by stimulation of the region of the upper extremity of the fissure of Rolando.

Below the leg area and partly in front of it, and occupying the middle third, or rather two-fourths of the central convolutions (Fig. 430, 3, 4, 5, 6, and *a*, *b*, *c*, *d*; and Fig. 431, "Arm"), is a centre for the movements of the upper extremity. The thumb may be individually thrown into action by stimulation of the ascending parietal convolution at the lower extremity of the intra-parietal fissure.

Occupying the lower third of the central convolutions, and consequently lying below the arm area, is a region stimulation of which gives rise to movements of the face, mouth, and tongue. Within this region can be differentiated centres for the upper facial muscles (Fig. 430, 7, 8) in front of and for the platysma (11) behind the fissure of Rolando.

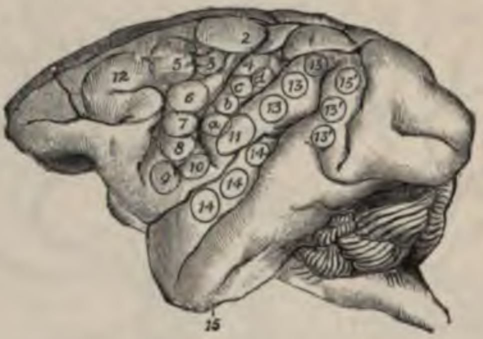


FIG. 430.—VIEW OF LEFT SIDE OF MONKEY'S BRAIN, WITH MOTOR AREAS MARKED (after Ferrier).

(1) The opposite hind limb is advanced as in walking; (2) flexion with outward rotation of the thigh, rotation inwards of the leg, with flexion of the toes; (3) the tail; (4) the opposite arm is adducted, extended, and retracted, the hand pronated; (5) extension forwards of the opposite arm; (*a*, *b*, *c*, *d*) movements of fingers and wrist; (6) flexion and supination of the forearm; (7) retraction and elevation of the angle of the mouth; (8) elevation of the ala of the nose and upper lip; (9 and 10) opening of the mouth with protrusion (9) and retraction (10) of the tongue; (11) retraction of angle of the mouth; (12) the eyes open widely, the pupils dilate, and the head and eyes turn to the opposite side; (13 and 13') the eyes move to the opposite side; (14) pricking of the opposite ear, head and eyes turn to the opposite side, pupils dilate widely.

Krause first demonstrated phonatory closure of the larynx in the dog on stimulation of the pre-sigmoid region. Semon and Horsley (No. 6, 1889, ii. p. 1383) have enlarged upon these observations, and locate the centre in the monkey as having its intensest point just posterior to the lower end of the pre-central sulcus in the anterior half of the foot of the ascending frontal convolution (see Figs. 431 and 433). It is apparently bilateral in its action. The movements of the cords elicited by stimulation of it are those of adduction. They have been unable to find a centre in the cerebral cortex for abduction of the

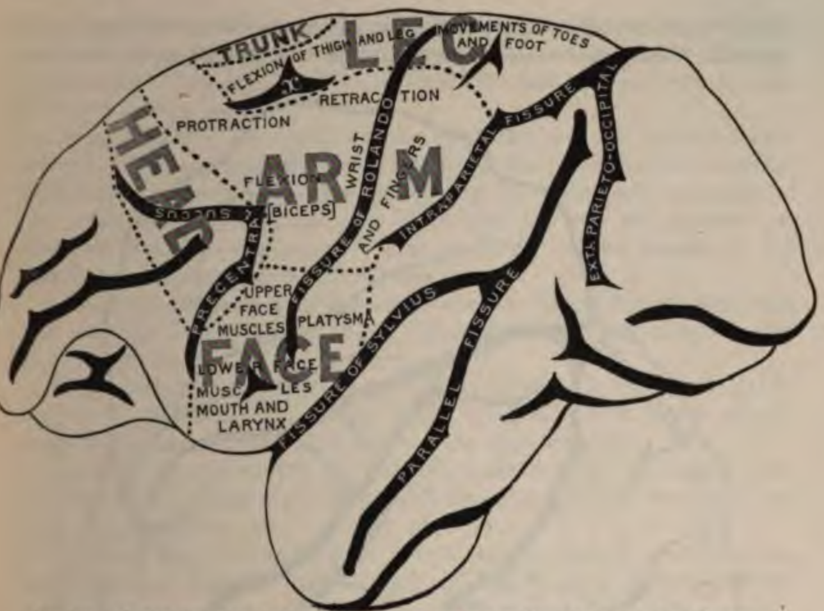


FIG. 431.—MOTOR CENTRES ON OUTER ASPECT OF CEREBRAL HEMISPHERE OF THE MONKEY (after Horsley and Schäfer).

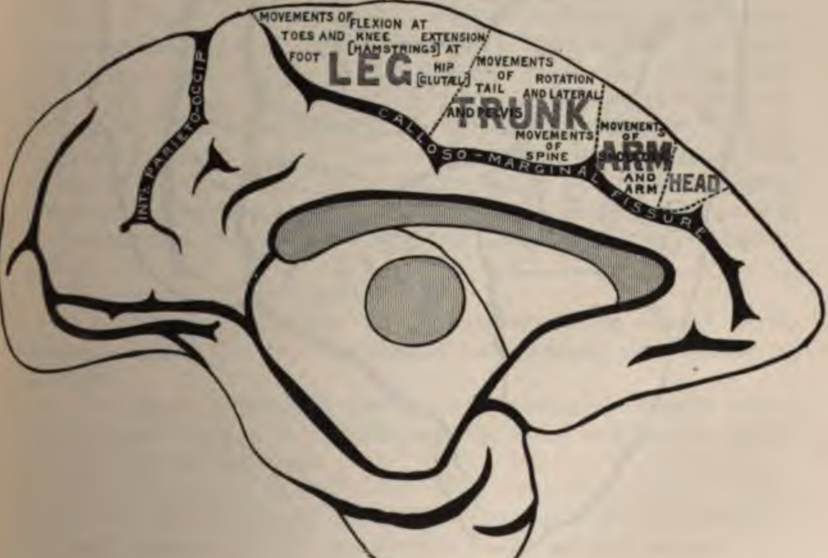

MOVEMENTS OF TOES AND FOOT
FLEXION AT KNEE [HAMSTRINGS]
EXTENSION AT HIP [GLUTÆI]
LEG
MOVEMENTS OF TAIL AND PELVIS
ROTATION AND LATERAL MOVEMENTS OF SPINE
TRUNK
MOVEMENTS OF SHOULDER AND ARM
ARM
HEAD
CALLOSO-MARGINAL FISSURE
INTL PARIETO-OCCIP

FIG. 432.—MOTOR CENTRES ON MESIAL ASPECT OF CEREBRAL HEMISPHERE OF THE MONKEY (after Horsley and Schäfer).

cords; but state that direct excitation of the accessory nucleus in the medulla oblongata evokes abduction of the cords, and never anything else.

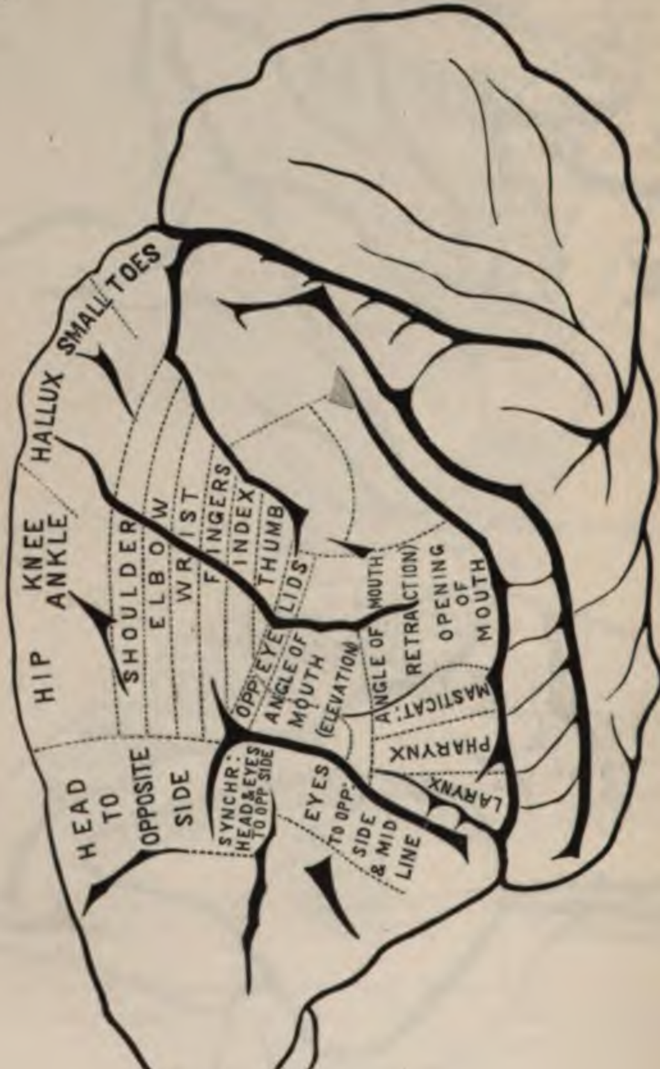


FIG. 431.—MOTOR AREAS ACCORDING TO BEEVOR AND HORSLEY.

Coming to the mesial aspect of the hemisphere, an important motor area is to be found in the marginal gyrus (Fig. 432). Horsley and Schäfer have demonstrated that excitation of this from before backwards causes movements of the spine, tail, and pelvis respectively; and, still farther back, extension of the hip, flexion of the leg, and movements of the foot and toes. These movements, however, are apt to run into one another.

Stimulation of the angular gyrus (Fig. 430, 13, 13′) induces movements of the eyeballs and occasionally of the head to the opposite side, generally combined with an upward or downward excursion of the eyeballs, according as the electrodes are on the anterior or posterior limb of the gyrus. The condition of the pupils is not constant; sometimes they are contracted.

It is questionable whether excitation of the occipital lobe gives rise directly to any motor effects, although it has been asserted that such is the case.

Stimulation of the first temporal gyrus (Fig. 430, 14) causes pricking of the opposite ear, opening of the eyes, dilatation of the pupils, and direction of the head and eyes to the opposite side.

Torsion of the nostril on the same side is said to be called forth by stimulation of the hippocampal lobule, or anterior extremity of the hippocampal gyrus.

Ferrier has been unable to obtain any constant reaction from stimulation of the rest of the temporal lobe or other portions of the cortex.

Cortical Motor Centres in the Brain of Man.

918. Coming now to the question of how far these motor centres of the monkey's brain are represented in the brain of Man, it is found that as a general statement the motor area in the one closely corresponds to that in the other. This has been ascertained—(1) by destructive lesions annihilating the function of the parts; (2) by stimulating lesions such as tumours, localised tubercles, etc., exciting the parts to action; and (3) by the application of a weak continuous or interrupted current, as a means of diagnostic localisation, to parts of the motor area exposed as a result of accident or after a trephine wound.

Thus it may be concluded—

(I.) That the motor area in Man appears to lie strictly in the neighbourhood of the convolutions surrounding the fissure of Rolando.

(II.) Generally speaking, the leg centres occupy the highest part of this, the arm centres the middle, and the facial and lingual centres the lower or opercular part.

(III.) The centre marked "12" (Fig. 430), stimulation of which causes opening of the eyes, dilatation of the pupils, and movements of the head and eyes to the opposite side, in the monkey, appears to be absent in Man.

The leg centre in Man was placed by Hallopeau and Girodeau at the upper limit of the ascending parietal and in the para-central

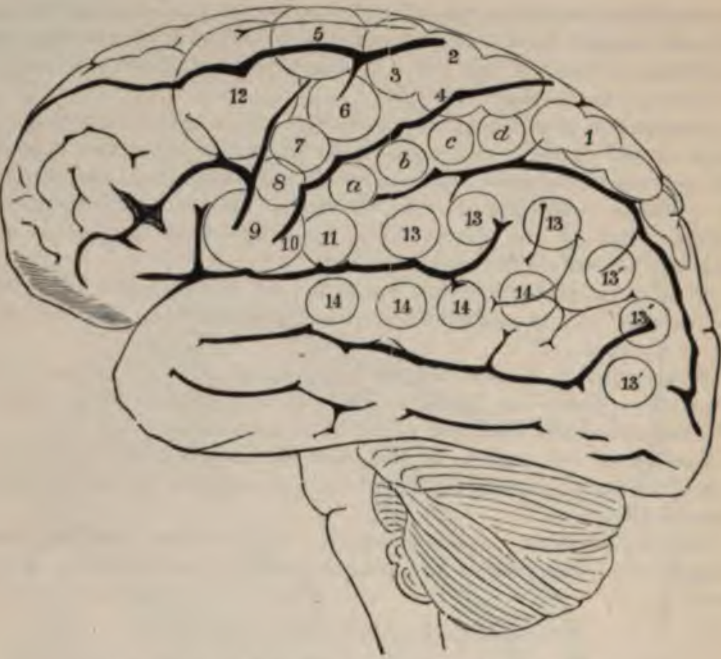


FIG. 434.—SIDE VIEW OF THE CORTEX OF THE HUMAN BRAIN.

The figures have been constructed by marking on a human brain, in their respective situations, the motor areas determined on the monkey's brain.

(1) *On the postero-parietal lobe.*—Advance of the opposite hind leg as in walking.

(2, 3, 4) *On the upper extremity of the fissure of Rolando.*—Complex movements of the opposite leg and arm, and of the trunk, as in swimming.

(*a*, *b*, *c*, *d*) *On the ascending parietal convolution.*—Individual and combined movements of the fingers and wrist of the opposite hand. Prehensile movements.

(5) *On the posterior extremity of the superior frontal convolution.*—Extension forward of the opposite arm and hand.

(6) *On the upper part of the ascending frontal convolution.*—Supination and flexion of the opposite forearm.

(7) *On the median portion of the ascending frontal convolution.*—Retraction and elevation of the opposite angle of the mouth by means of the zygomatic muscles.

(8) *Lower down on the same convolution.*—Elevation of the ala nasi and upper lip, with depression of the lower lip on the opposite side.

(9, 10) *At the inferior extremity of the ascending frontal and posterior extremity of the third frontal convolution.*—Opening of the mouth with (9) protrusion and (10) retraction of the tongue. (*Region of aphasia.*)

(11) *At the inferior extremity of the ascending parietal convolution.*—Retraction of the opposite angle of the mouth, the head turned slightly on one side.

(12) *On the posterior portions of the superior and middle frontal convolutions.*—Eyes opening widely, pupils dilating, and the head and eyes turning towards the opposite side.

(13, 13') *On the supra-marginal lobule and angular gyrus.*—The eyes moving towards the opposite side, with an upward (13) or downward (13') deviation. Pupils generally contracting. (*Centre of vision.*)

(14) *On the infra-marginal or superior temporo-sphenoidal convolution.*—Pricking up of the opposite ear, head and eyes turning to the opposite side, and pupils dilating largely. (*Centre of hearing.*)

The centres of *taste* and *smell* are at the *extremity of the temporo-sphenoidal lobe*, and that of *touch* in the *gyrus uncinatus and hippocampus major* (Ferrier).

lobule, emulging upon the upper part of the ascending frontal, anteriorly, and the superior parietal lobule, posteriorly. Charcot and Pitres placed it in the para-central lobule.

The centres for the arm lie apparently in the middle of the ascending frontal and parietal convolutions—that is to say, opposite the base of the second frontal. The thumb centre referred to as present in the monkey also prevails in Man. Stimulation of it often serves as a useful guide to the locality.

The centre for the movements of the vocal cords in the monkey has already been referred to (p. 616). Rossbach (No. 140, xlvi. 1890, p. 159) holds that in Man it is located in the island of Reil, and quotes a case at length in support of this.

Permanent Effects of Destructive Lesions of the Motor Part of the Cortex.

When the motor centres of the cortex in Man are once destroyed, their function never seems to be taken on by any other part of the brain. In animals lower in the scale, however, such as the dog, this does not appear to be the case.

Thus Goltz found (No. 169, xxxiv. 1884, p. 450) that when the motor cortex in a dog is completely removed bilaterally there is not anything like the permanent loss of motor power exhibited by Man when portions of this area are destroyed. The animal for the first few days is in a stupid and torpid condition. It neither tends to stand nor to walk, and does not take nourishment voluntarily, but swallows well enough when food is placed in its mouth. Consciousness, which is lost at first, returns in a few hours.

In two months after the operation is completed the animal has so far recovered as to be able to walk, stand, run, and spring, but all these movements are executed clumsily and are unapt. In walking, for instance, the hind feet are approached; and if the animal is set on a table it jumps down readily but awkwardly. Obstacles are avoided with certainty in walking.

The conclusion that is generally drawn from these facts is that in the dog the basal ganglia have not become so functionally obsolete as in Man, and that they are capable, in a manner, of assuming the functions of the motor centres of the cortex when these are rooted out.

What seems most extraordinary, however, if true, is the statement made by Sherrington (No. 179, vi. p. 178) that in those dogs which have recovered their motor power, and which present merely this clumsiness of movement, both pyramidal tracts may be found to be completely destroyed.

Cortical Centres for Tactile and Painful Sensibility.

919. The method of testing the functions of these centres by stimulation in animals is impracticable. The method of excision has accord-

ingly been resorted to for this purpose. Even this method, however, in its finer details will ever remain inconclusive. The ultimate appeal must be to lesions of the brain in Man.

From the examination of 169 selected cases in Man, Exner (No. 546) came to the conclusion, among other things, that the area for tactile sensibility lies in the motor areas for the extremities. The sensitive field, however, is never an absolute one, and shows less intensely than the motor. Each sensitive cortical field, he further asserted, stood in relation to both halves of the body. His observations seemed to be borne out by cases collaterally and subsequently recorded by Tripier (No. 521, iii. 1880-81, p. 286), v. Monakow (No. 517, xi. 1881, p. 613), Petrina (No. 521, vi. 1883, p. 137), Bechterew (No. 134, ccxi. 1886, p. 82), and others. Evidence of anæsthesia or analgesia, or of special painful sensations, were said to accompany certain lesions in which cortical paralysis of motion formed the main feature. One characteristic of these sensory phenomena is that they are never so prominent as the motor, and, so far as known, the loss of sensibility is never complete.

The experimental evidence adduced by Munk (No. 547) seemed to lend some basis of support to the above observations made in Man. In this country, however, numerous objections have been raised to the view that the cortical motor areas are also sensory in function. There has been a tendency rather to localise the centres for tactile and painful sensibility in particular convolutions having a much narrower limit than is presupposed in the above.

Thus Ferrier (No. 548, p. 323) found that destruction of the hippocampal region in monkeys produced more or less complete loss of tactile sensibility in the opposite side of the body.

Later on, these experiments were repeated by Horsley and Schäfer (No. 65, clxxix. 1888, B, p. 1, also Reprint), and when the destruction of the parts in this neighbourhood was sufficiently extensive, with practically the same results. The condition of hemianæsthesia, however, although fairly well marked in some cases, was never complete, and disappeared within a week of the operation.

On extending their experiments, the last-mentioned observers discovered that any extensive lesion of the gyrus fornicatus is followed by hemianæsthesia more or less marked and persistent. In some cases the anæsthetic condition involved almost the whole of the opposite side of the body, in others it was localised to particular parts. Seeing that the gyrus fornicatus is practically continuous with the gyrus hippocampi, the two constituting the great *limbic lobe* of Broca, they regard their results not as antagonistic, but rather as an extension of those of Ferrier. Their observations seem, therefore, to point to the limbic lobe being largely, if not exclusively, concerned in the appreciation of both painful and tactile sensations.

Schiff (see summary of his views by Huggard, No. 59, 1885, ii. p. 194) takes the view that in the dog and several other vertebrates the so-called motor centres are merely tactile centres, and that, when they are excised, the difficulty the animal has in its movements is due to loss of tactile sensibility, not to loss of actual motor power. The ablation of the motor area in the dog permanently abolishes tactile sensibility on the opposite side of the body, but sensibility to pain and motility are retained. The effects are somewhat different in the monkey.

Lesions of the Prefrontal Region.

920. By the prefrontal region in Man is understood that part of the frontal lobe which lies anterior to the motor centres. Every one

seems to be agreed in asserting that stimulation of this region in the lower animals does not call forth any motor response, and when it is destroyed in Man, motor paralysis is not one of the phenomena accompanying the destruction.

The commonest diseases of this region, apart from the results of direct injury, are tumours, such as round-celled sarcomata, porencephalic absorption, etc.

When extensive destruction from any cause has taken place in early youth or infancy, the individual's mental capacity is warped or remains unevolved. Where the lesion is extensive, more or less imbecility is noticed. In a case which the author had the opportunity of examining, both frontal lobes were extensively damaged, and on the right side the prefrontal region was entirely wanting. The individual, a woman, was over fifty years of age at the time of death, and had remained a complete imbecile for the whole of her life. It was impossible to instruct her in even the most rudimentary matters. She was quite incapable of understanding the meaning of the letters of the alphabet, although seeing and hearing perfectly; indeed it was questionable whether she recognised the significance of the coloured pictures in the ward, which, however, in some way fascinated her. She was completely aphasic, walked with some difficulty, and was barely competent to attend to her mere animal wants. Her intelligence had apparently made no advance from the time of her earliest childhood.

Similar cases have been recorded, and usually with very much the same history.

When the prefrontal region is destroyed in after-life marked deterioration is noticed in all the higher qualities which distinguish Man from the brute creation, and not unfrequently the deterioration takes a criminal bias (see case reported by Ferrier, No. 521, v. 1883, p. 62). Goltz found (No. 169, xxxiv. 1884, p. 450) that, when the frontal region was removed in the dog, the disposition of the animal changed for the worse. It became snappish and pugnacious, and would attack a big dog of which formerly it stood in awe.

Cortical Auditory Centre.

921. Although Hughlings Jackson has stated, and probably quite correctly, that no case is known of complete deafness in Man induced by a cortical lesion, yet both experimental and pathological facts indicate that the temporo-sphenoidal lobe, and more particularly the first temporal convolution, is the most important, if not the only storehouse of acoustic images. The condition known as "word-deafness" clearly points to this being at least the receptive centre for the accumulation of the memories of spoken language. It is impossible, however, to discuss this subject apart from that of aphasia, under which heading further information is given.

Munk has invented the term "psychical deafness (*Seelentaubheit*)" to express that condition in which the animal or individual hears well enough, but fails to interpret what the sounds mean, and "cortical deafness (*Rindentaubheit*)" to indicate that the animal's powers of hearing are impaired or lost from a cortical lesion. Similar terms have been long used in reference to lesions of the visual centre (Sect. 951).

Baginsky's experiments would seem to show that the auditory nerve is placed in connection with the centre for hearing through the inferior fillet of the opposite side. His experiments consisted in destroying the labyrinth in rabbits, and tracing the consequent degeneration of the paths below. The fibres of the lower fillet of the opposite side show a marked shrinkage.

Cortical Visual Centre.

922. There are chiefly two views on the subject—(1) that held by Munk, to the effect that it resides in the occipital lobes alone, and that complete cortical blindness may be induced by their bilateral removal; and (2) that held by Luciani and Tamburini (No. 551; see also No. 521, ii. 1880, p. 234), and lately adopted by Ferrier, that in the monkey the angular gyri are also concerned with vision, and that in order to produce perfect cortical blindness both angular gyri and both occipital lobes must be annihilated.

The subject, however, cannot well be treated apart from the other lesions of vision, and the reader is accordingly referred to *Diseases of the Optic-conducting Apparatus, and of the Centres connected with it* (Chap. LXXXIII.).

Cortical Olfactory Centre.

923. There is some amount of accumulated evidence in favour of the hippocampal lobule being the seat of the sense of smell. Lesions calculated to cause irritation of this neighbourhood have been known to give rise to subjective sensations of smell. The case of an epileptic is referred to by H. Jackson and Beevor (No. 521, xii. 1890, p. 346), where coexistent with the presence of a tumour in the temporo-sphenoidal lobe the "aura" took the form of a horrible smell. They refer to several other cases of the same kind.

Literature on Cerebral Localisation.—**Anderson and Makins** (Topography): Journ. of Anat. and Physiol., xxiii. 1888-89, p. 455. **Ashby** (Tum. of Thal. with Choreiform Movements): Med. Chron., Manch., v. 1886-87, p. 117. **Beevor and Horsley** (Monkey's Motor Area): Phil. Trans., clxxix. 1889, p. 205. **Birdsall** (Hemianopsia): N. York Med. Journ., xlv. 1887, p. 469. **Blanc** (Cortical Centre of Conjugate Deviation): Lyon méd., lii. 1886, p. 145. **Bleuler** (Pons Lesion and Eye Movements): Deut. Arch. f. klin. Med., xxxvii. 1885, p. 527. **Broca,** see APHASIA. **Carville and Duret** (Critique): Compt. rend. Soc. de Biol., v. 1874, p. 374. **Charcot:** Localisation in Brain Disease, 1883, Eng. transl., N. Syd. Soc. **Dodds:** Journ. Anat. and Physiol., xii. 1877-78, pp. 340, 454, 636. **Eisenlohr**

(Central Paralysis of Larynx): Arch. f. Psychiat., xix. 1888, p. 314. **Eulenburg**: Berl. klin. Wochnschr., xiii. 1876, p. 619. **Exner**: Localisation der Functionen in der Grosshirnrinde des Menschen, 1881; *also*, Wien. med. Wochnschr., xxxvi. 1886, pp. 1665, 1699. **Exner and Paneth** (Cortical Origin of Facial): Arch. f. d. ges. Physiol., xli. 1887, p. 349. **Ferrier**: The Localisation of Cerebral Disease, 1878; *also*, The Functions of the Brain, 1886; *also*, Brain, xii. 1889, p. 36; *also* (Croonian Lectures), Lancet, 1890, i. p. 1225 *et seq.*; *also*, separate publication. **Fritsch and Hitzig**: Arch. f. Anat. Physiol. u. wissensch. Med., 1870, p. 300. **Glover**: Arch. de neurol., xvi. 1888, pp. 39, 249. **Goldstein**: Schmidt's Jahrb., clxxxiv. 1879, p. 281. **Goltz**: Physiologie des Froschhirns, 1885; *also*, Arch. f. Psychiat., xviii. 1887, p. 268. **Gowers** (Brain in Congenital Absence of one Hand): Brain, i. 1878, p. 388. **Gray** (Lesions of both Temp. Lobes without Word-Blindness or Word-Deafness): Journ. Nerv. and Ment. Dis., xi. 1886, p. 554. **Günther**: Ztschr. f. klin. Med., ix. 1885, p. 1. **Hitzig**: Untersuch. üb. d. Gehirn, 1874. **Horsley** (Motor Centres): Notices Proc. Roy. Inst. Gr. Brit., x. 1884-86, p. 250; *also* (Motor Centres and Will), Nature, xxxii. 1885, p. 377. **Horsley and Schaefer** (Cerebral Cortex Expers.): Phil. Trans., clxxix. 1889, p. 1. **Huggard** (Excitable Area of Cortex): Lancet, 1885, ii. p. 194. **Jackson and Beevor** (Tumour of Temp. Sph. Lobe bearing on Sense of Smell): Brain, xii. 1889-90, p. 346. **Kœnig** (Gumma of Thalamus): Arch. f. path. Anat., cvii. 1887, p. 191. **Laborde** (Cerebral Peduncles): Trav. Lab. physiol. Fac. méd. de Par. (1884), 1885, i. p. 99. **Lussana and Lemoigne** (Motor): Arch. de physiol. norm. et path., iv. 1877, pp. 119, 342. **Macewen** (Arm and Leg Centre): Lancet, 1885, i. p. 934. **Meyer** (Degeneration of the Fillet): Arch. f. Psychiat., xvii. 1886, p. 439. **Mickle** (Brachial Centre): Journ. Ment. Sc., xxxi. 1885-86, p. 47. **Mills** (Cerebral Localisation in its Practical Relations): Trans. Washington Med. Cong., 1888. **Munk**: Berl. klin. Wochnschr., iii. 1877, p. 505; *also* (Visual Centre), Arch. f. Physiol., 1878, pp. 162, 547, 599; 1879, p. 581; *also*, Ueb. d. Functionen d. Grosshirnrinde (reprint of articles published from 1877-80), 1881. **Ord** (Gumma of L. Motor Area): St. Thomas' Hosp. Rep., xv. 1886, p. 227. **Ott** (Heat Centres): Journ. Nerv. and Ment. Dis. N. Y., xiii. 1888, p. 85. **Paneth**: Arch. f. d. ges. Physiol., xxxvii. 1885, p. 523. **Rabl** (Facialis): Anat. Anzeig., ii. 1887, p. 219. **Ranney**: Lectures on Nervous Diseases, 1888. **Rickards** (Hæmorrhage into Crura Cerebri): Brit. Med. Journ., 1886, i. p. 774. **Rossbach** (Voice Centre): Deut. Arch. f. klin. Med., xlvi. 1889-90, p. 140. **Rühmekorb**: Ein Beitrag zur Lehre v. d. Localisation im Grosshirn, 1889. **Savill** (Anæsthesia and Trophic Changes from Lesion of Gyrus Fornicatus): Brain, xiv. 1891-92, p. 270. **Schmidt** (Destruct. of Tegmentum, Thalami, Corp. Striat., and Nuc. Lent. without Loss of Sensation or Motion): Journ. Nerv. and Ment. Dis., x. 1885, p. 294. **Semon and Horsley** (Larynx Centre): Brit. Med. Journ., 1889, ii. p. 1283. **Sharkey** (Atrophy of Brain from Spinal Paralysis): Brain, xi. 1888-89, p. 94. **Spitzka** (Localisation in Pons-Oblongata Transitional Area): Journ. Ment. and Nerv. Dis. N. Y., xi. 1886, p. 193. **Starr** (Sensory Tract): Journ. Nerv. and Ment. Dis., ix. 1884, p. 327; *also* (Thrombosis of Artery in Tegmentum): Journ. Nerv. and Ment. Dis., xiv. 1887, p. 115. **Treitel and Baumgarten** (Hemianopsia and Syphilis): Arch. f. path. Anat., cxi. 1888, p. 251. **Wernicke** (Lesion of Lower Parietal Neighbourhood): Arch. f. Psychiat., xx. 1888, p. 243.

CHAPTER LXXX

THE NERVOUS SYSTEM—(*Continued*)

GENERAL STRUCTURE OF THE BRAIN IN RELATION TO DISEASE.

924. BEFORE going further it may be advantageous to lay before the reader a short sketch of the position occupied by the component parts of the great brain, as revealed by serial section in the three directions of space. Sections I. to IX. are made in a perpendicular transverse direction, Sections X. and XI. run horizontally, while Section XII. is obliquely sagittal.[1]

Perpendicular Transverse Sections.

Section I. (Fig. 435) runs through the middle of the third frontal convolution and corresponding parts of the first and second frontal convolutions.

If this part of the brain is examined in the fresh condition the white matter appears to be undifferentiated. It seems to be uniformly opaque, and it is impossible to track out the course of its fibres. When prepared, however, by the gelatine-potash method employed in making the sections from which the above figure was taken, *three tracts of fibres* are exposed whose direction is evidently different from the surrounding mass. That which lies mesially (Tr. int.) is the largest; the middle (Tr. med.) is a more delicate slip; and the most external (Tr. ext.) again is of considerable size. Without entering further into what they mean, let it suffice that the innermost tract, or **tractus internus corporis callosi,** contains the most anterior of the callosal fibres which are about to cross to the opposite side, as well as those which have already crossed. The middle tract, or **tractus medius corporis callosi,** is composed of some of the callosal fibres which have already crossed, and which are circumventing the anterior horn of the ventricle: while the most external tract, or **tractus externus corporis callosi,** contains chiefly fibres derived from a like source as those of the middle tract, but also a certain proportion from the prefrontal region of the same side. Both sets of fibres are passing backwards. It will be noticed that this last of the three tracts lies very closely underneath the third frontal convolution.

---

[1] The appearances delineated are those revealed by the author's gelatine-potash method (see vol. i. p. 48).

Section II. (Fig. 436) passes through the third frontal convolution a little farther back than Section I.

It shows the **first** and **second frontal convolutions** above (1 Fr. and 2 Fr.) and the **gyrus rectus** and **gyrus orbitalis** below. The **tractus internus,** described in the foregoing section, has now become the **genu of the corpus callosum** (G. C. C.), the point where the two tracts coalesce being that exposed. The **tractus medius** and **externus** (Tr. med. and Tr. ext.) are still visible in their old positions. On the right side, the tip of the **lateral ventricle** (L. V.) may be noticed, and the com-

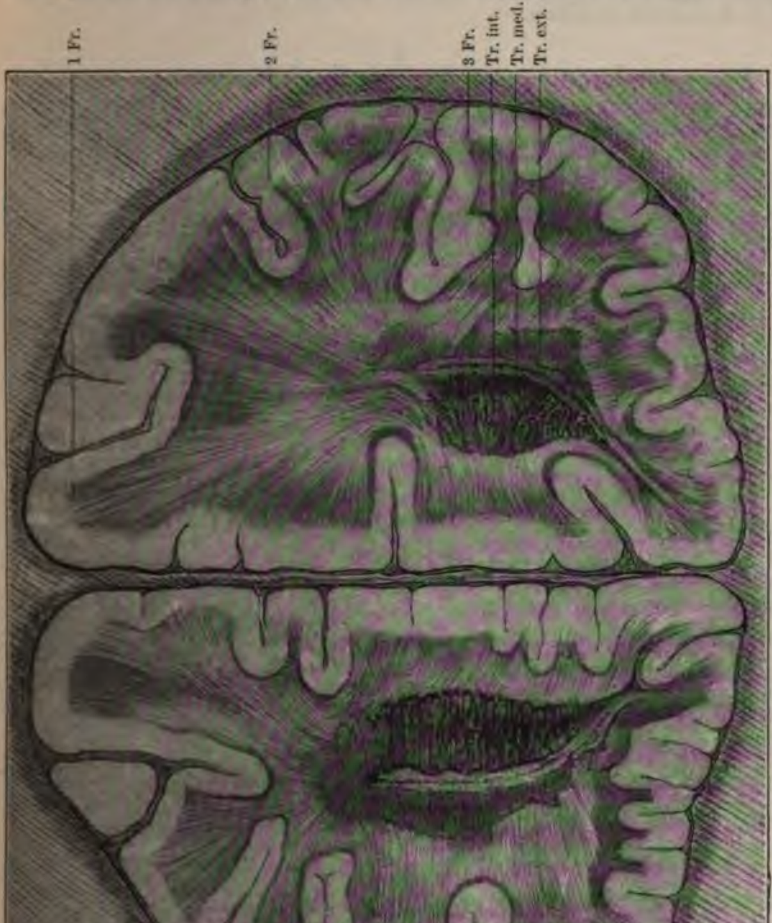


Fig. 435.—Perpendicular Transverse Section of Cerebrum through Anterior Aspect of Third Frontal Convolution (see text).

mencement of the **Sylvian fissure** (S. F.) The distance (X.) intervening between the tractus externus and the gray matter of the third frontal convolution is even less than in the previous section.

Section III. (Fig. 437) runs through the tip of the temporo-sphenoidal lobe (T. S. L.) and the operculum.

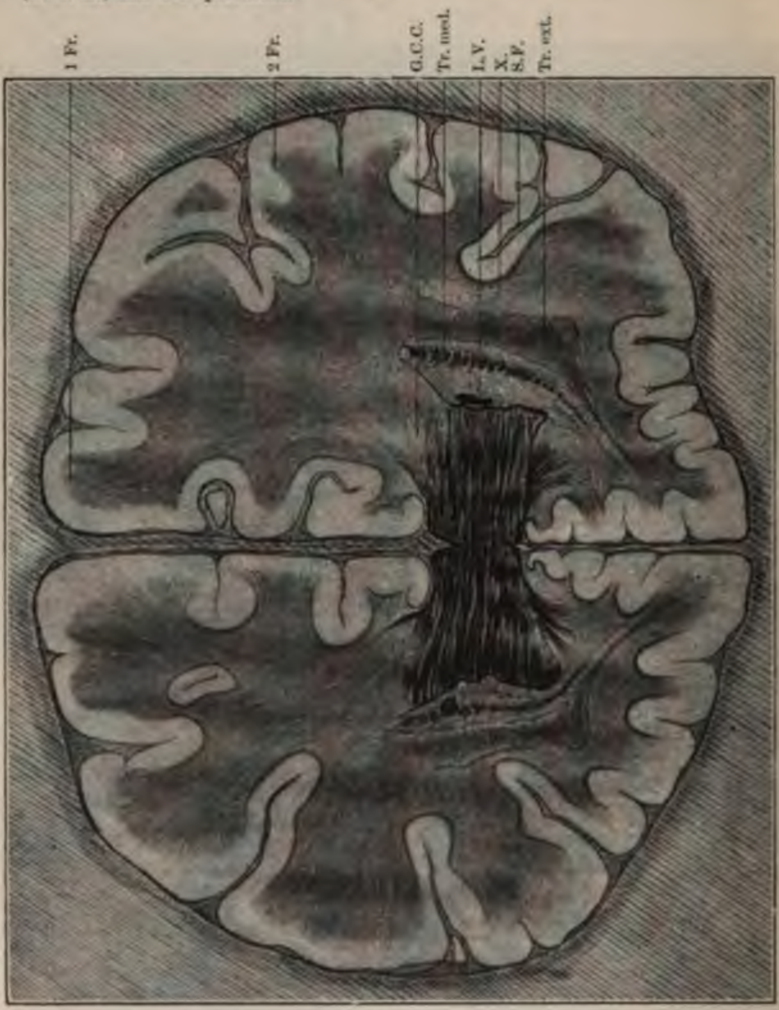


Fig. 436.—Perpendicular Transverse Section of Cerebrum a little behind Section I., cutting through the Genu Corporis Callosi (see text).

The **surrounding convolutions** are the following: Starting from the mesial aspect inferiorly, the gyrus rectus (G. R.) and the gyrus orbitalis are seen. The convolutions of the temporo-sphenoidal lobe (T. S. L.) and those of the island of Reil (I. R.) are placed more externally; the ascending frontal (As. Fr.) and the second (2 Fr.) and first frontal (1 Fr.) lie above; while forming the boundary wall of the great longitudinal fissure are the marginal convolution (M. C.), and beneath it, immediately above the corpus callosum, the gyrus fornicatus (G. F.) The internal parts exposed by this section are now much more complex and of the greatest importance. Running interhemispherically is the **corpus callosum** (C. C.), and immediately beneath it the **septum lucidum** (S. L.) enclosing the **fifth ventricle,** while on either side of the latter is the anterior extremity of the **lateral ventricle.** A somewhat pear-shaped mass of gray matter, the **corpus striatum**, is seen outside of this, split into two by a coarse mass of white fibres, the **inner capsule** (I. C.) The outer division is the head of the **lenticular nucleus** (L. N.), the inner the head of the **caudate nucleus** (C. N.) A little farther forwards they coalesce, but at this level, as just said, they are separated by a coarse band of white fibres, the inner capsule. The lenticular nucleus is bounded externally by the **outer capsule** (O. C.), while external

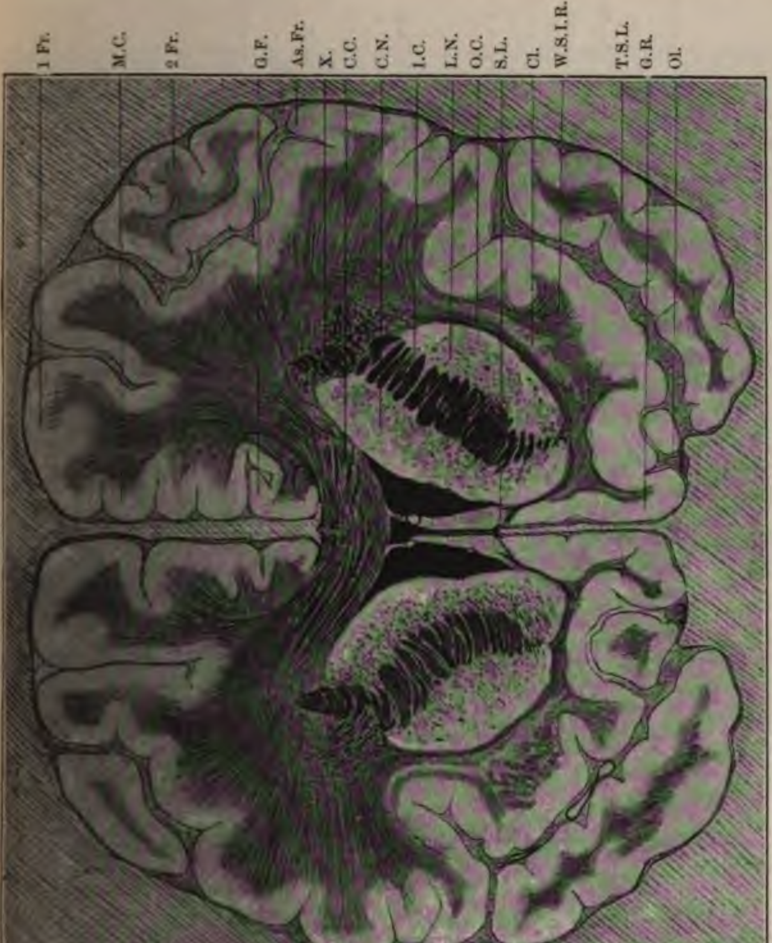


FIG. 437.—PERPENDICULAR TRANSVERSE SECTION OF CEREBRUM THROUGH THE HEADS OF THE CAUDATE AND LENTICULAR NUCLEI (see text).

to this again is the **claustrum** (Cl.), the **white substance of the island of Reil** (W. S. I. R.), and the gray convolutions of **the island** itself. The **olfactory tract** (O. T.) is seen lying in the sulcus olfactorius.

Section IV. (Fig. 438) runs through the tip of the temporo-sphenoidal lobe just anterior to where it joins on to the brain substance generally. The first (1 Fr.), second (2 Fr.), and ascending frontal convolutions (As. Fr.) form the convex upper and outer border of the section.

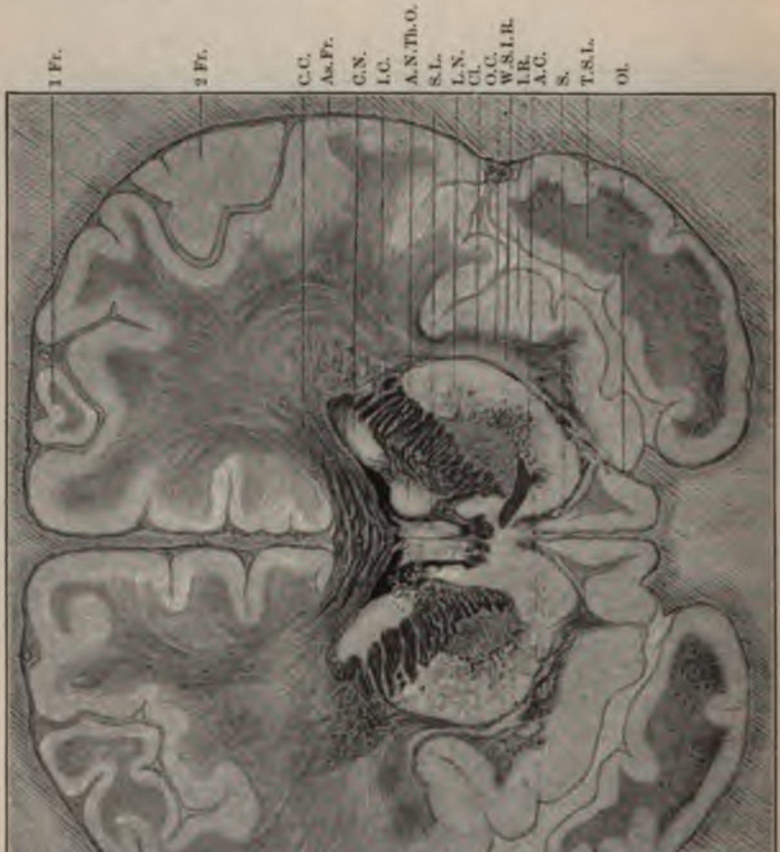


FIG. 438.—PERPENDICULAR TRANSVERSE SECTION OF CEREBRUM THROUGH THE TIP OF THE TEMPORO-SPHENOIDAL LOBE (see text).

The **corpus callosum** (C. C.) is seen stretching interhemispherically, and at each side of it there is a slight indication of the fibres of the **crossed callosal tract** turning downwards (see Sect. 926). The **caudate nucleus** (C. N.) is now becoming reduced in bulk, while the **lenticular nucleus** (L. N.) is divided into an outer and inner segment by one of the striæ medullares. The inner of the two segments, being the more fibrous, appears darker than the outer. This section reveals the most anterior limit of the **thalamus,** its so-called **anterior nucleus** (A. N. Th. O.) The **inner capsule** (I. C.) separates the caudate nucleus and the thalamus on the one hand from the lenticular nucleus on the other. Lying immediately below the tapering lower extremity of the inner capsule is a dense band of white fibres, the **anterior commissure** (A. C.). The **olfactory tract** (O. T.) is still visible, but, from its having broken up into its several roots, presents a flattened-out appearance. At this point a root can be seen to come off and to pass up directly into the outer capsule.

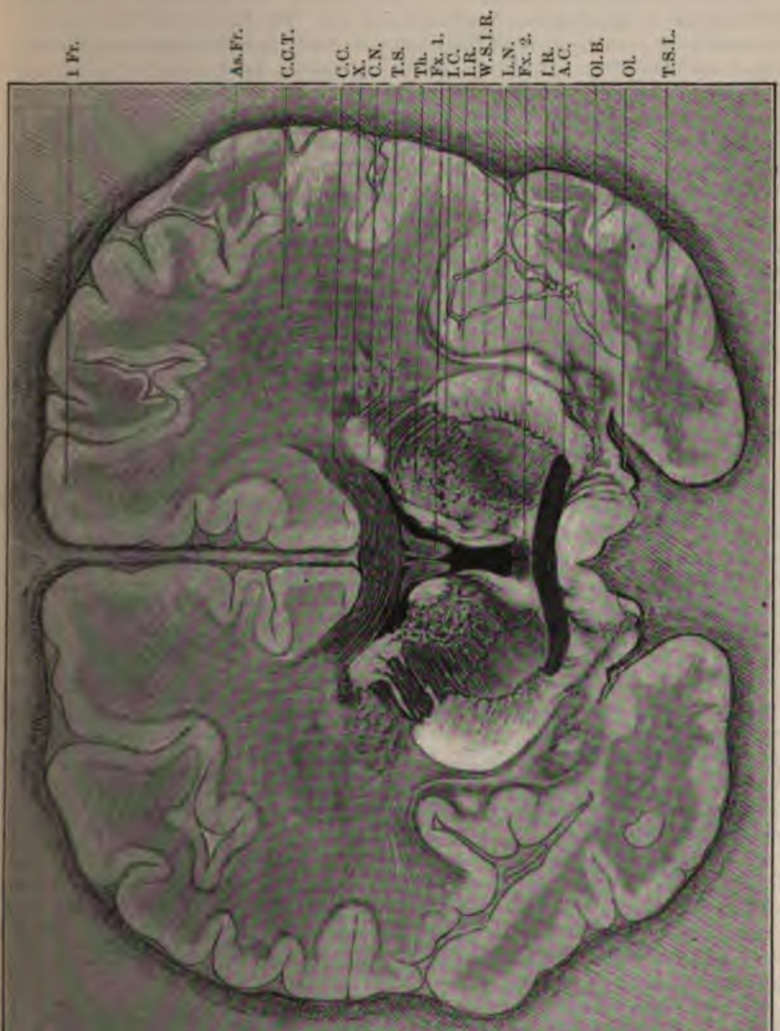


FIG. 439.—PERPENDICULAR TRANSVERSE SECTION OF CEREBRUM THROUGH THE ANTERIOR COMMISSURE (see text).

Section V. (Fig. 439) cuts through the organ immediately behind the coalescence of the temporo-sphenoidal lobe with the rest of the hemisphere.

Over and above the parts previously referred to, it gives a full view of the **anterior commissure** and its branches to the olfactory (Ol.). Ferrier (No. 548, p. 316) seems to doubt this connection of the olfactory with the anterior commissure, but it appears to the author on insufficient grounds. The direction of these olfactory fibres given off from the anterior commissure is clearly from the temporo-sphenoidal lobe of one side of the brain through the commissure, down towards the roots of origin of the opposite olfactory. Not that the entire commissure is composed of them; they form only a component part of it. By their mediation the olfactory is connected with the temporo-sphenoidal lobe of the opposite side, a connection quite in keeping with what is known of the cortical centre of smell.

On both sides, but more particularly on the left, the connection of the olfactory with the outer capsule, seen in Section IV., is also plainly visible. The two divisions of the lenticular nucleus (L. N.) are well demarcated by one of the striæ medullares. The arch of the fornix (Fx. 1) and the two receding pillars lying on the floor of the third ventricle (Fx. 2) are also brought into view.

Section VI. (Fig. 440) runs through the **infundibulum.** It cuts across the temporo-sphenoidal lobe (T. S. L.), the ascending frontal (As. Fr.), and first frontal convolutions (1 Fr.).

The central parts have undergone considerable transformation. Firstly, it will be seen that the **caudate nucleus** (C. N.) is much smaller than previously, and that it has also lost its fibrous appearance. The part represented is taken from about its middle third. Projecting from the mesial convexity of the inner capsule on the left side is a fibrous-looking mass, the **thalamus opticus.** The **lenticular nucleus** (L. N.) is divided into four segments on the left, and into three on the right side by the striæ medullares.

Under the lenticular nucleus is a double bundle of fibres (I. P. Th.) running from the region of the thalamus down to the temporo-sphenoidal lobe, and terminating in the nucleus amygdalaris (N. A.). This has been called the **lower peduncle of the thalamus** by Meynert, and the part of the central gray matter through which it passes in its course beneath the wedge-shaped extremity of the lenticular nucleus, is known as the **substantia innominata of Reil.** The **anterior commissure** (A. C.) is now seen divulging on the right side into the temporo-sphenoidal lobe, its fibres splitting up into a brush-like mass, to be distributed to probably the whole of the temporal convolutions. To the outside of the external segment or **putamen** of the lenticular nucleus (L. N.) comes in the **outer capsule** (O. C.), now thoroughly differentiated; beyond the latter is the slip of gray matter called the **claustrum** (Cl.); still farther out is some white matter (W. S. I. R.) underlying the convolutions of the island and known as the **substantia innominata** or **white substance of the island**; while most externally lies the **gray matter of the island** itself and the **Sylvian fossa.**

Let us direct our attention for a moment to the outer capsule at this point. It is composed of an outer and an inner layer. The *outer layer* comes from the operculum and runs into the temporo-sphenoidal lobe chiefly to the first temporal convolution. As will be seen, the opercular region and the temporo-sphenoidal lobe are also freely united by the white matter of the island, which a little farther back (Fig. 441) becomes a prominent object. The *inner layer* of the capsule comes from above and passes downwards in great part to unite with the anterior commissure. Where its fibres reach to after this it is hard to say. Quite likely they cross by means of the anterior commissure to the opposite side of the brain to enter the olfactory tract.

The **ventricular system** is seen to take the form of the letter Y. The stem of the letter is represented by the third ventricle, the two limbs by the lateral ventricles. The point of junction is the so-called **foramen of Monro**. The lateral ventricles are covered by the **corpus callosum,** and hanging from the lower aspect of the corpus callosum is the somewhat heart-shaped section of the arch of the **fornix** (Fx. 1). The walls of the ventricles, it will be observed, are placed in close apposition. The optic tract (O. T.) lies on each side of the tuber cinereum and its infundibulum (In.).

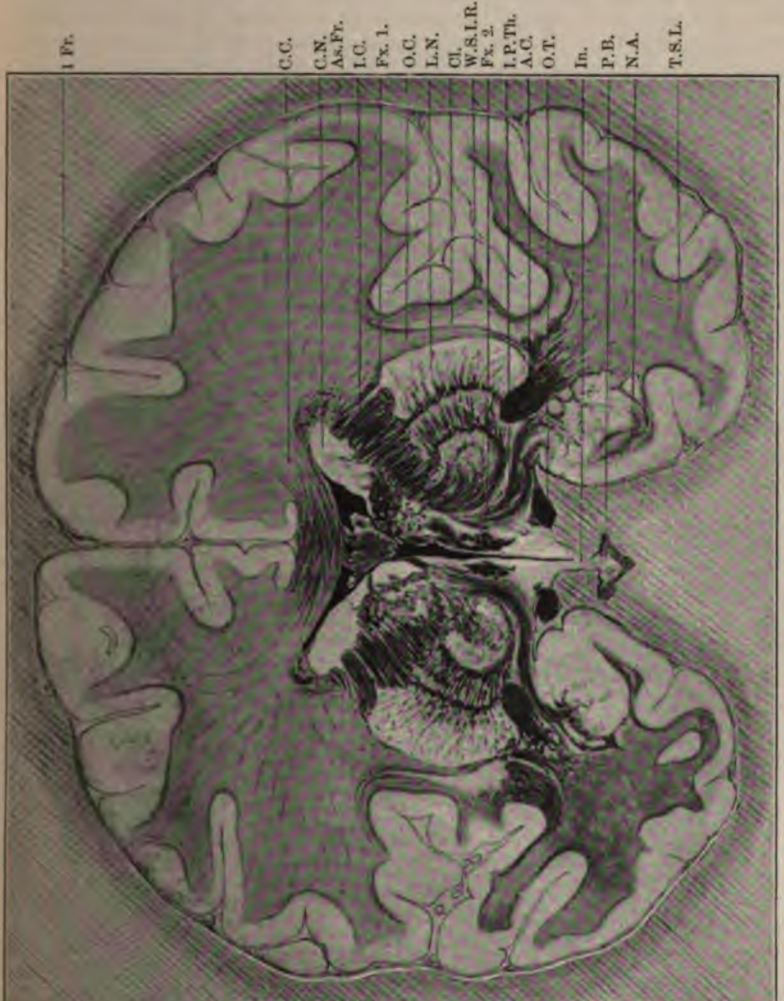


FIG. 440.—PERPENDICULAR TRANSVERSE SECTION OF CEREBRUM THROUGH THE INFUNDIBULUM AND PITUITARY BODY (see text).

Section VII. (Fig. 441) cuts through the corpora albicantia (C. A.), and gives a view of the thickest part of the thalamus (Th.).

Notice how very fibrous the **thalamus** appears to be, more so than any other member of the basal ganglia. On the upper free border is a little clear mass, its **anterior nucleus**, enveloped by the fibres of the stratum zonale or white covering of the ganglion.

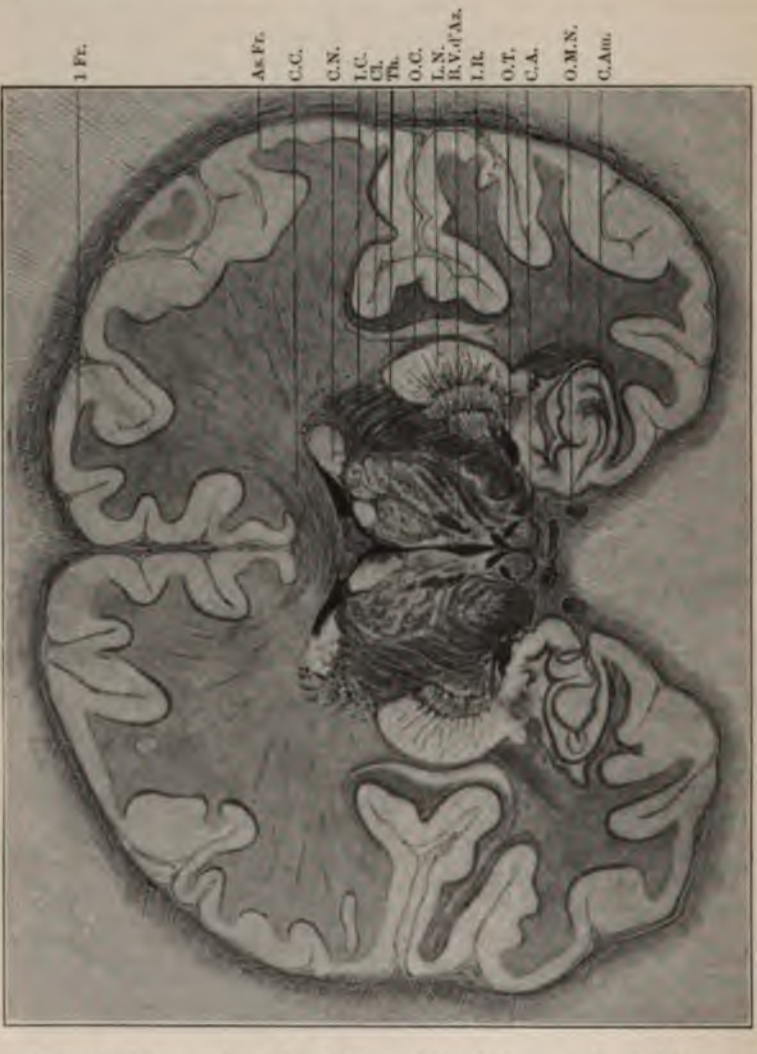


Fig. 441.—Perpendicular Transverse Section of Cerebrum through the Corpora Albicantia (see text).

On the left side, the **inner capsule** (I. C.) has emerged on the base of the brain, and constitutes the commencement of the **cerebral peduncle**. Twisting round the corpora albicantia (C. A.) are the prolongations backwards of the **fornix**. In the two preceding figures (Sects. V. and VI., Fx. 2) the fornix limbs may be seen running backwards within the gray matter lining the third ventricle, and now, in this, they make a figure-of-eight twist round the corpus albicans to terminate by splitting up in the thalamus. One of the main bands into which the fornix is continued is seen in the midst of the thalamus—the band of Vicq d'Azyr (B. V. d'Az.). There are, however, many others whose destination cannot be entered upon at present. A difference of opinion prevails as to whether the bundles which thus end in the thalamus are all directly continuous with the body of the fornix, or whether they are reinforced from the gray matter of the corpus albicans itself. The anterior commissure has lost the character of a compact bundle. Part of its brush-like mass of terminal fibres is still noticeable.

The position of the **optic tract** (O. T.) in this and the following figure is worthy of special attention. It lies close beneath the lenticular nucleus (L. N.), and is adherent to it and to the emerging fibres of the crus cerebri. A localised hæmorrhage, tumour, or other lesion in the posterior part of the lenticular nucleus, exerting pressure, will thus compress the tract and occasion symptoms of *hemiopia* (see Sect. 949). Cases of this kind are not very uncommon. The author met with one quite lately, in which a focal hæmorrhage into the lenticular nucleus in the situation indicated caused complete hemiopia.

Section VIII. (Fig. 442) cuts through the anterior margin of the **Pons Varolii.** The parts exposed are much too complex to allow of detailed description in the small amount of space at our command.

The **thalamus** (Th. Th.) bulks largely in this section. Lying on its mesial border is an oval-shaped mass of gray matter (M. N. Th.), which, irrespective of the many ambiguous nomenclatures proposed, let us name its **median nucleus.**

Below the thalamus and between it and the pons is that area of mixed gray and white matter known as the **regio subthalamica.** Within it are seen two well-defined ganglia. The one is the **red nucleus** (R. N.), and the other the so-called **corpus Luysianum** (C. L.). Lying to the outer side of this region are the peduncular fibres (P. F.) descending into the pons. The **triangular-shaped space** situated between the two corpora Luysiana and below the third ventricle is caused simply by the divergence of the two cerebral peduncles. The Y-shape of the **ventricular cavity** is well displayed, the **foramen of Monro** or the channel of connection between the lateral and third ventricles being located at the point F. M. The **outer capsule** in this region is particularly bulky, more so than in any other part of the brain. Its fibres seem to pass directly downwards into the temporo-sphenoidal lobe. The commencement of the tail of the caudate nucleus is shown at C. N_1; its termination (the surcingle) in the descending horn of the lateral ventricle at C. N_2. The **lenticular nucleus** is fast diminishing in size, to terminate a short way farther back.

The so-called **tænia semicircularis** is seen cropping out between the caudate nucleus (C. N_1) and the thalamus (Th.). It is seen to be continuous below with the **lamina medullaris externa,** that series of bundles of fibres forming the outer boundary wall of the latter ganglion.

Section IX. (Fig. 443) passes across the front of the angular gyrus. Above is the **lobulus parietalis superior,** while below, and internally or mesially, are the occipito-temporal convolutions. In the centre is the posterior horn of the lateral ventricle (L. V.).

As will be seen, we have now passed behind the basal ganglia in our progress backwards. To the inner side of the ventricle is the remainder of the corpus callosum (C. C.), while below this and continuous with it is the little eminence of white fibres known as the **hippocampus minor.**

To the outside of the ventricle are two well-defined ribbon-like bands of fibres cut across. The inner of these is known as the **tapetum** (Tap.), the outer is the **parieto-occipital band** (P. O. B.), or the tract which contains the fibres coming forwards from the occipital and part of the parietal lobes. The latter used to be called **Gratiolet's optic radiations,** from the fact that Gratiolet regarded it as part

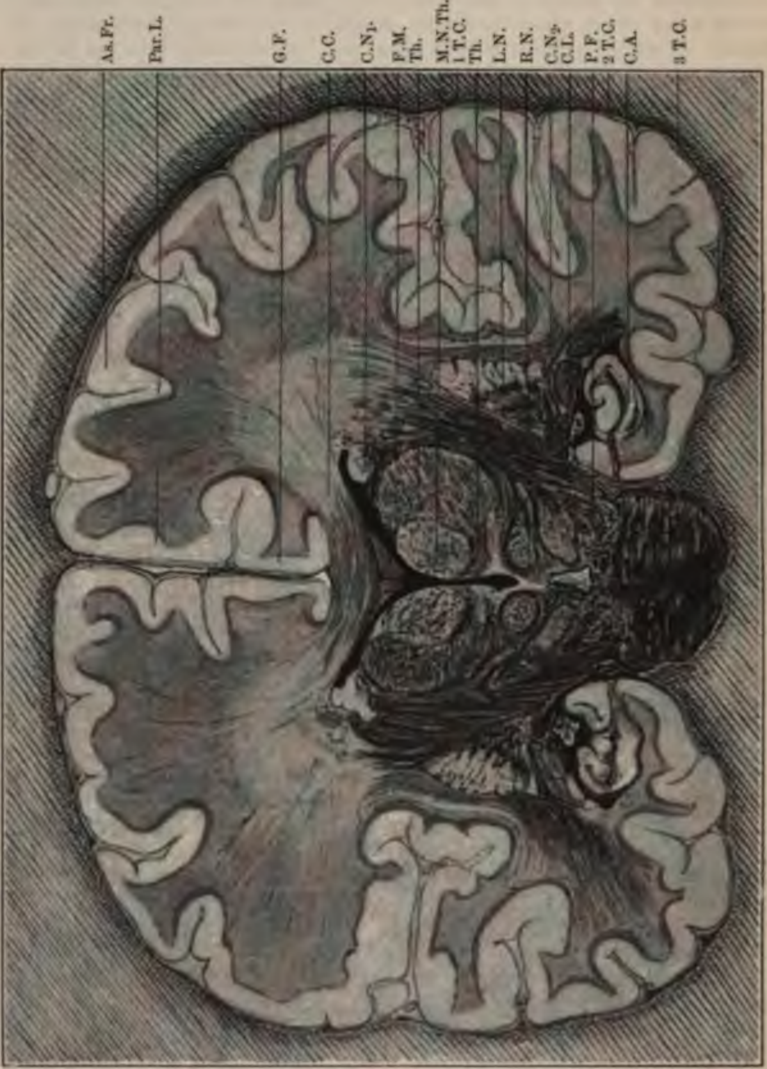


Fig. 442.—Perpendicular Transverse Section of Cerebrum through Front of the Pons (see text).

of the cerebral expansion of the optic tract. We now know that it does contain optic fibres, but that it is not wholly composed of these.

The lower part of the figure represents an oblique section through the cerebellum, fourth ventricle, and medulla oblongata.

Horizontal Sections.

Section X. (Fig. 444) was drawn from an opaque section. Like the others, it was outlined by an actual tracing. It ought, however, to be contrasted with Fig. 445, which was taken from a transparent preparation, as the latter brings out certain points which this does not, owing to the different manner of viewing it.

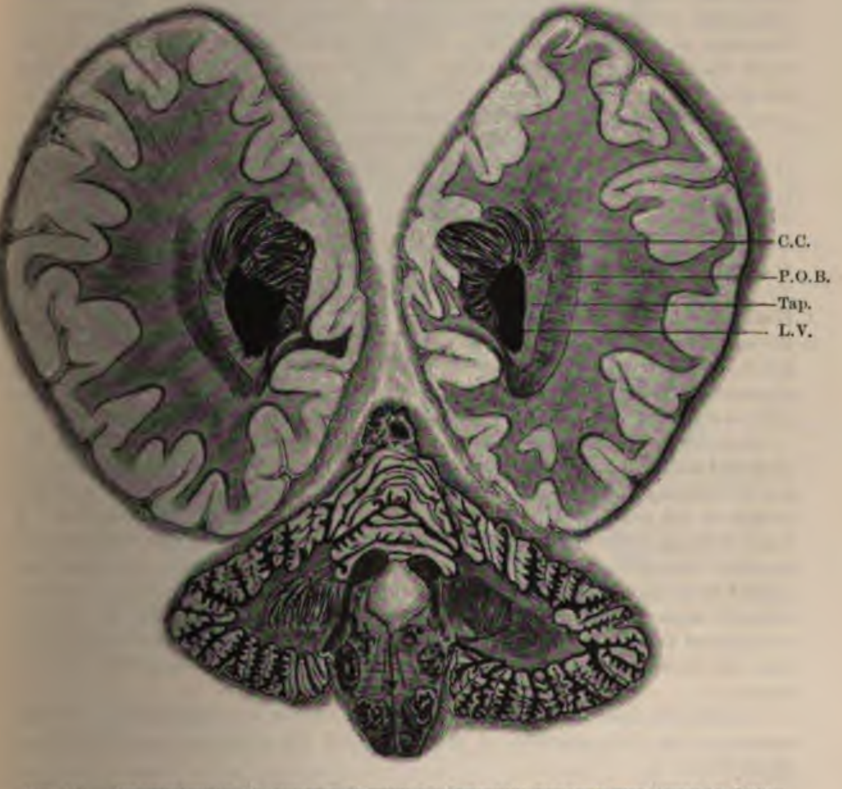


FIG. 443.—PERPENDICULAR TRANSVERSE SECTION OF CEREBRUM THROUGH THE ANGULAR GYRUS, AND (OBLIQUE) OF THE CEREBELLUM AND MEDULLA OBLONGATA (see text).

It passes through the brain at such a level as to afford perhaps the most instructive picture of the parts of greatest importance. The convolutions displayed are the first, second, and third frontal. Behind these comes the island of Reil lying in the Sylvian fossa; and still farther back, the temporo-sphenoidal and occipital lobes. In front, little differentiation of the white matter is perceptible, owing to the preparation being opaque.

Attached to the posterior extremity of the corpus callosum (C. Call.) are in respective sequence the **septum lucidum** with its enclosed **fifth ventricle,** the **anterior commissure,** and the **anterior pillars of the fornix.** Behind this again come the **third ventricle,** the **commissura mollis** uniting the two thalami, and still farther back the continuation of the third into the fourth ventricle, or the **aqueduct of Sylvius.** As the last of these runs in a direction from below, upwards and backwards, it is cut off obliquely.

A very instructive view is had of the **basal ganglia.** Thus in front, pushing its way into the lateral ventricle, is the tuberose head of the caudate nucleus; while behind and to the outer side lies the lenticular nucleus, three of its segments being seen in the whole of their horizontal extent. Observe that the outer segment of the lenticular nucleus is separated from the head of the caudate nucleus only by the inner capsule. The bands of striæ medullares, which are the means of subdividing the lenticular nucleus into segments, are continuous with the anterior limb of the inner capsule in front, and with the posterior limb of the same behind.

Looked at on horizontal section it will be seen how numerous and complex the connections of the **inner capsule** are, and what a large proportion of its fibres find their destiny in the thalamus. It is divided into an anterior and a posterior limb. As compared with the posterior limb, the anterior at this level is comparatively slender. It is evident, further, that many of the fibres in the anterior limb, as it is at present seen, run almost directly backwards and terminate in the optic thalamus. To these fibres Meynert long ago gave the name of the **anterior peduncle of the thalamus.** Notice, also, what a large number of fibres leave the posterior limb of the capsule (P. L. I. C.) to enter the thalamus lying to its mesial side. It is these which, on penetrating the gray matter of this ganglion, give it the peculiarly fibrous appearance previously referred to. Lying within the thalamus pretty far forwards are two cross-cut bundles (Fig. 445, B. V. da), the **bands of Vicq d'Azyr.**

Posterior to the thalamus come in two oval-shaped gray masses on each side, the **external and internal geniculate bodies,** and more towards the middle line are two of the **corpora quadrigemina,** probably the anterior. The white layer on the surface of the geniculate bodies is the apparent termination of the optic tract. A band of the optic can also be seen stretching towards the corpora quadrigemina and partially enveloping them. Outside the external geniculate body, and lying embedded in the anterior wall of the middle horn of the lateral ventricle, is a little rounded mass of gray matter, the **tail of the caudate nucleus.** It will be remembered that the tail of the caudate nucleus is very long, and extends far down into the middle horn of the ventricle. It is cut across consequently in this section.

Outside the base of the lenticular nucleus lie the outer capsule, the leaf-like claustrum, the white substance of the island, and the corresponding convolutions of the same.

Coming still farther back, the **descending or middle horn of the ventricle** is seen with the corrugations of the **cornu Ammonis** within it. At one point the junction of the fornix with the cornu Ammonis is exposed. Notice that the gray matter of the cornu is nothing more than a continuation of the cortical gray matter.

Section XI. (Fig. 445).—The view of the parts given in this drawing is somewhat out of keeping with that of Section IX., owing to the plane of section not having been exactly horizontal. It is higher posteriorly and lower anteriorly than that of Section X., so that the splenium of the corpus callosum is exposed, while the continuity of the limbs of the inner capsule is interrupted by the anterior commissure. It is, however, a very instructive figure for our purposes, and, moreover, having been taken from a transparent section, displays certain connections unrevealed by one in which the original has been opaque. The parts brought into view, unfortunately, are so intricately united and so very complex that it is

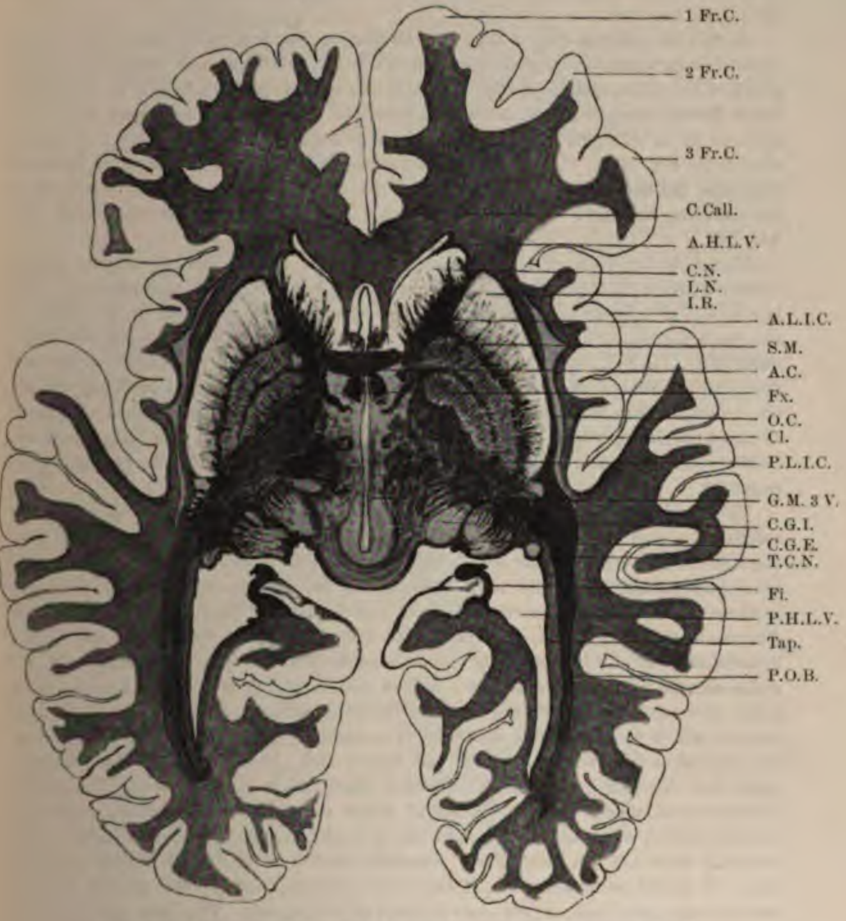


Fig. 444.—Horizontal Section. Human Brain (Opaque Preparation).

(1 Fr.C.) First frontal convolution; (2 Fr.C.) second frontal convolution; (3 Fr.C.) third frontal convolution; (C.Call.) corpus callosum; (A.H.L.V.) anterior horn, lateral ventricle; (C.N.) caudate nucleus; (L.N.) lenticular nucleus; (I.R.) island of Reil; (A.L.I.C.) anterior limb, inner capsule; (S.M.) striæ medullares; (A.C.) anterior commissure; (Fx.) anterior pillars of the fornix; (O.C.) outer capsule; (Cl) claustrum; (P.L.I.C.) posterior limb, inner capsule; (G.M. 3 V.) gray matter, third ventricle; (C.G.I.) corpus geniculatum internum; (C.G.E.) corpus geniculatum externum; (T.C.N.) tail caudate nucleus; (Fi) fimbria with adjacent cornu ammonis; (P.H.L.V.) posterior horn, lateral ventricle; (Tap) tapetum; (P.O.B.) parieto-occipital band.

impossible here to do much more than merely refer to them. The wondrous interweaving of the fibres in a preparation such as this drawing was taken from gives some idea of the intricate manner in which the different regions of the organ are bound together.

It will be noticed that about the middle of the prefrontal region there lies a somewhat pyriform or leg-of-mutton-like tract (*a*). Turning back to the description given of the perpendicular section through this region (p. 626), it will be found that three bands were described as being exposed, the direction of whose fibres was referred to as different from those of the surrounding white substance. They are shown in Fig. 435. This is the innermost of the three, the **tractus internus corporis callosi.** A little band is noticed outside of this. It is a portion of the **tractus medius**; while outside of this again is the **tractus externus** (Fig. 445, *b*).

The anterior limb of the inner capsule (*d*) is represented by a few disconnected bundles of fibres, but the posterior limb (I. C.) is thick and massive. The latter is close upon the level where its fibres emerge upon the base of the brain as the pedunculus cerebri. Passing down the middle line we come to the **third ventricle** (III. V.), and in the gray matter on each side of it are, in front, the **two descending pillars of the fornix** (Fx.), and behind, the **bands of Vicq d'Azyr** (B. V. da); while still farther back is the **posterior commissure**, with segments of the **anterior corpora quadrigemina** (C. Q. A.). Beyond the last-mentioned bodies, on each side, is the pointed extremity of the thalamus known as the **pulvinar.**

The **parieto-occipital band** or Gratiolet's optic radiation has been already referred to, and is depicted on transverse section in Fig. 443. It is now seen throughout its entire course (O. R. G.). Notice that it commences in the occipital lobe, and passing forwards as a ribbon-like compact tract, splits opposite the hind extremity of the posterior limb of the inner capsule into two contingents. *The one to the outer side* runs forwards to the middle of the *island of Reil*, where it terminates chiefly by spreading out in a somewhat fan-shaped expansion in the white substance of the island. It is met at the extremity of its course by a similar brush of fibres derived from the third frontal convolution. In the series of preparations of which the one being described is a member, nothing could be clearer than this extensive connection between the island and the occipital lobe on the one hand and the island and the third frontal convolution on the other. The middle of the island, where the two bands of fibres mingle (unnamed white substance of the island), is peculiarly opaque. It is a question as to whether some of the occipital fibres are not also carried forwards directly to the third frontal convolution. It would seem almost as if they were, although by far the greater number undoubtedly terminate in the convolutions of the island. The part of the third frontal from which the above fibres take origin is the posterior third to half of its extent.

In its course forwards towards the island, however, the parieto-occipital band will be seen to give off numerous fibres, which find their destination in the *temporal convolutions.* It is these which are probably bound up with the pathology of *word-blindness* (p. 670).

Fibres also stream into it from the parietal convolutions, and run forwards. They serve to increase its bulk, so that, at the point anteriorly where it divides, it has quite twice the size it had in the parieto-occipital region.

The other contingent into which this parieto-occipital band divides lies mesially or internally to that just described as passing to the island. Its fibres are distributed among other parts to *the thalamus* and *the geniculate bodies*, while a large

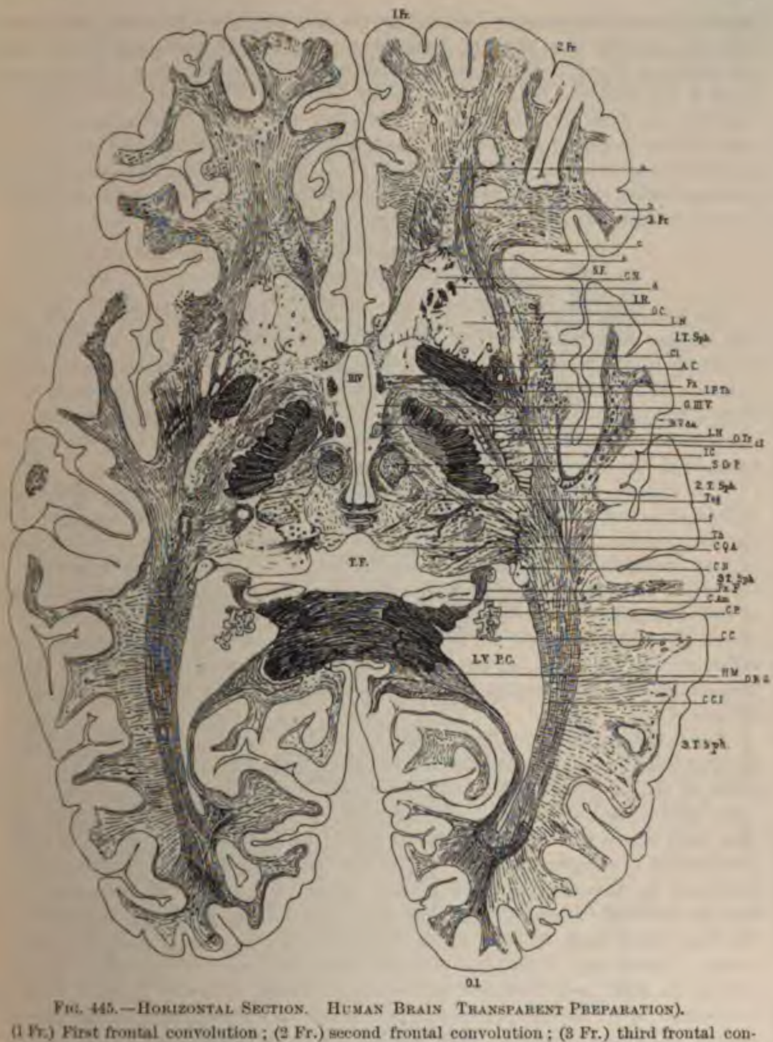


FIG. 445.—HORIZONTAL SECTION. HUMAN BRAIN TRANSPARENT PREPARATION).

(1 Fr.) First frontal convolution; (2 Fr.) second frontal convolution; (3 Fr.) third frontal convolution; (I.R.) island of Reil; (1 T.Sph.) first temporo-sphenoidal convolution; (2 T.Sph.) second temporo-sphenoidal convolution; (3 T.Sph.) third temporo-sphenoidal convolution; (O.L.) occipital lobe; (T.F.) transverse fissure; (III. V.) third ventricle; (*a*) internal callosal tract; (*b*) external callosal tract; (*c*) fibres from third frontal convolution turning into outer capsule; (*e*) association fibres connecting the third frontal convolution and island of Reil; (S.F.) Sylvian fossa; (*d*) a few fibres of anterior limb of inner capsule; (O.C.) outer capsule; (L.N.) lenticular nucleus; (Cl.) claustrum; (A.C.) anterior commissure; (Fx.) fornix; (I.P.Th.) inferior peduncle of thalamus; (G.III.V.) gray matter, third ventricle; (B.V. da) band of Vicq d'Azyr; (O.Tr.) optic tract; (I.C.) inner capsule; (S.Cr.P.) superior cerebellar peduncle and red nucleus; (Teg.) tegmentum; (*f*) fibres of the occipito-parietal band, spreading forwards into the island of Reil and first and second temporo-sphenoidal convolutions; (Th.) posterior extremity of thalamus; (C.Q.A.) corpus quadrigeminum anterius; (Fx.F.) fimbria of fornix; (C.Am.) cornu Ammonis; (C.P.) choroid plexus; (C.C.) corpus callosum; (H.M.) hippocampus minor; (O.R.G.) optic radiations of Gratiolet, or parieto-occipital band; (C.C.F.) tapetum.

mass of them sinks into the *posterior part of the capsule* to descend in the peduncle. This is probably the **sensory band**, whose destruction occasions crossed hemianæsthesia. Many of the fibres, however, take another direction. They pass in front of the posterior limb of the capsule forwards and inwards, twist round the capsule and enter the thalamus. Presumably this is the continuation of what Meynert has described as the **lower peduncle of the thalamus**, and which is seen on perpendicular section in Fig. 440, I. P. Th. It is impossible, at present, to detail the many other points of interest shown in this Figure. The above will be sufficient for our present purposes.

Obliquely Sagittal Section.

Section XII. (Fig. 446).—The plane of section in the preparation from which this Figure was taken ran not exactly antero-posteriorly, but with sufficient deviation to the side to pass through medulla, pons, crus cerebri, and farther onwards in the same line. The convolutions exposed are those therefore of the frontal and parietal lobes as far back as the splenium of the corpus callosum. The occipital lobe does not come into view, but a small detached segment of the temporo-sphenoidal lobe is seen inferiorly. The preparation was transparent.

The **corpus callosum** (*c.c.*) is cut off obliquely and the course of its fibres within the centrum ovale is faintly indicated anteriorly. The little slip of white matter (*f*) seen underneath its splenium is a segment of the **fornix**. The continuity of the **lenticular** (*l.n.*) and **caudate nuclei** (*c.n.*) anteriorly is apparent, the separation being only partial and effected through the somewhat interrupted bundles of the anterior limb of the inner capsule. Abutting on the caudate nucleus behind comes the **thalamus** (*th*) with its various nuclei and terminal **pulvinar**, while following out the same convex line formed by these three large nuclei are the two corpora quadrigemina (*c.q.*). The Figure terminates with a section of the cerebellum (*cl*).

Below the lenticular nucleus are seen two bands obliquely cut across. The one in front (*a.c.*) is the anterior commissure, that behind is the optic tract (*o*). The fibres of the posterior limb of the inner capsule are seen descending in the pedunculus cerebri, and are continued downwards in the crusta or its superficial layer. The layer above this is the substantia nigra; while above that again and beneath the corpora quadrigemina is an indefinitely fibrous layer, the tegmentum, covered in above by the corpora quadrigemina (*c.q.*). The fibres of the crusta (*p.c.*) can be followed down through the pons (*p*). They split up into numerous bundles, which again coalesce at its lower limit to pass into the medulla oblongata (*m.o.*). Interlacing with them are the cross-cut transverse fibres of the pons derived in great part from the cerebellum. Passing obliquely upwards from the cerebellum is the superior cerebellar peduncle (*s.c.p.*), losing itself in the tegmental region. The olivary body (*ol*) is exposed in the medulla oblongata.

PLAN OF THE CENTRAL NERVOUS SYSTEM.

925. The general view upheld at the present day regarding the plan or architecture of the central nervous system is in its main features something like the following:—

Coming down from what has been lately called by Sherrington the **cord area** of the cerebral cortex, and which corresponds in Man pretty closely with what is named the motor area of the cortex, there are certain fibres which descend to the lowest limits of the spinal cord. They are known as pyramidal fibres, and run down through the inner capsule, crus cerebri, and pons to the medulla oblongata, where they partly decussate to enter the spinal cord. A good many of them are motor in function.

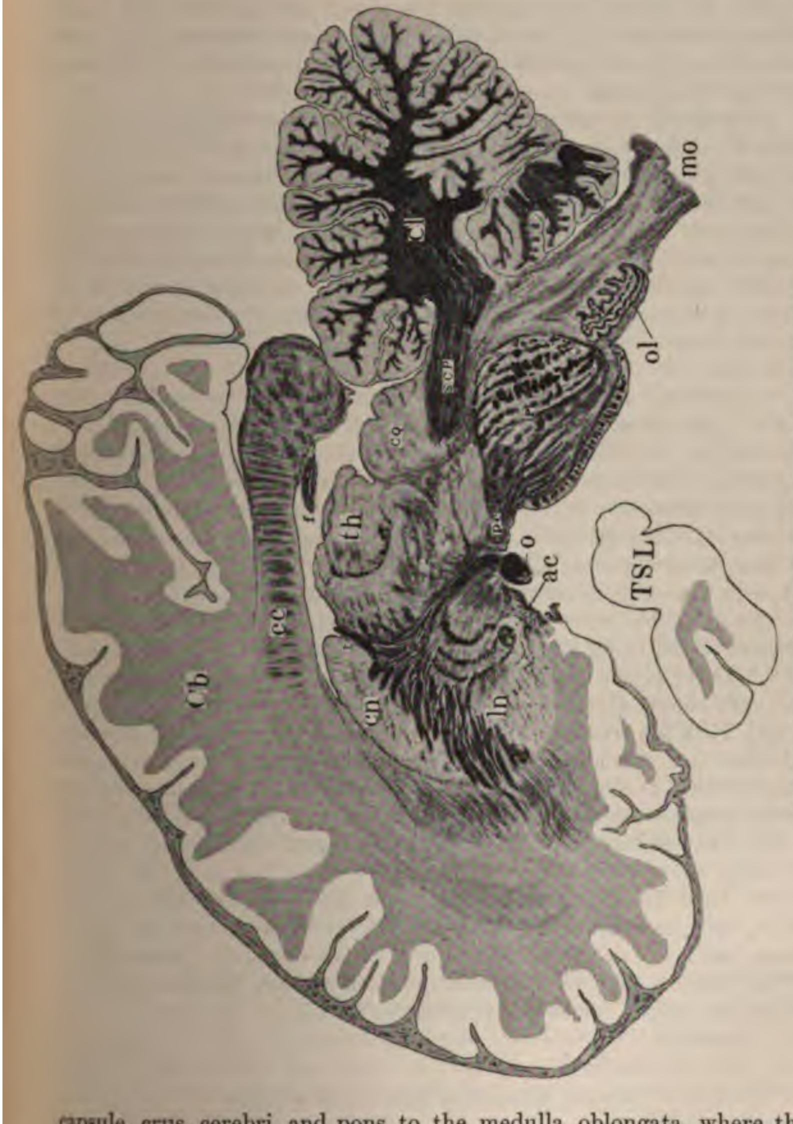


FIG. 446.—SLIGHTLY OBLIQUE SAGITTAL SECTION OF HUMAN BRAIN.

(*Cb*) Cerebral hemisphere; (*c.c.*) corpus callosum; (*cl*) cerebellum; (*m.o.*) medulla oblongata; (T.S.L.) temporo-sphenoidal lobe; (*c.n.* caudate nucleus; (*th*) thalamus; (*l.n.*) lenticular nucleus; (*a.c.*) anterior commissure; (*o*) optic chiasma; (*p.c.*) pedunculus cerebri; (*c.q.*) corpora quadrigemina; (*s.c.p.*) superior cerebellar peduncle; (*p*) pons; (*ol*) olivary body; (*t*) taenia semicircularis; (*f*) fornix.

From the basal ganglia fibres radiate upwards towards the cerebral cortex in a fan-shaped expansion known as the **corona radiata.**

Corresponding parts of the cerebral cortex are united through the various white commissures.

The cerebellum is put in connection with the cerebrum by means of its *superior peduncle*. Its *middle peduncle* runs across the pons; and through its *inferior peduncle* and corpora restiformia it communicates with the spinal cord.

The paths for the conveyance upwards of different peripheral impressions, paths for the conveyance of impressions to arouse feelings of painful and tactile sensibility, sense of location of a limb, sense of temperature, etc., are conveyed to the spinal cord by the posterior nerve roots, or to the brain by the sensory roots of the trigeminus. Those which enter the cord either pass to the opposite side at once and ascend in the gray matter (pain and temperature) to the cortex of the cerebrum, or run up in the posterior columns of the same (sense of location) or opposite side (tactile sensibility), the former decussating in the pyramids.

The farther stretch of the fibres upwards is questionable. The case of gliomatous tumour of the posterior horn of the spinal cord recorded by Rossolimo (No. 517, xxi. 1890, p. 897) would seem to favour the view that after decussating in the cord or anterior pyramids they pass into the interolivary layer, the lemniscus (Schleife) of the pons and cerebral peduncle. At least, the secondary degeneration in his case, resulting from destruction of the left posterior horn of gray matter in the cord, followed this ascending course.

The next we know of the sensory tract is that it occupies the posterior third or fourth of the posterior limb of the inner capsule, but where its fibres are ultimately distributed to, remains a mystery. There are chiefly three views on the subject:—

(1) That the sensory and motor centres of the cortex are separate, and that the ascending sensory fibres are applied directly to the sensory centres alone, the communication between them and the motor being by means of connecting or commissural fibres.

(2) That at least the tactile perceptive centres are bound up with the motor centres of the cortex.

(3) That the afferent fibres run up to the excitable portions of the cortex, and that thence impulses are conveyed to the motor centres whose locality is as yet undetermined. The so-called "motor area" of the brain would thus, according to this view, be the "sensitive perceptive centre" for tactile sensibility (Schiff).

Course followed by the Callosal Fibres.

926. Although such may be, in general terms, the common notion of the various great paths throughout the brain and cord, it by no

means follows that it is unassailable. Indeed there are good reasons for believing that in some most fundamental points it is radically wrong, in none perhaps more so than in the following:—

As mentioned above, the corpus callosum is generally regarded as *a commissure* uniting equivalent parts of the cortex and bringing them into functional harmony. If this be so it is difficult to understand, as in the example reported by Eichler (No. 517, viii. 1878, p. 355), and in many others, how so large a mass of white matter can be congenitally absent without a single indication during life.

The author for some years past has taken a different view of the meaning of the corpus callosum, and accumulating facts have so strengthened his belief in the theory he originally enunciated in a communication to the Royal Society of London,[1] that he has been in a manner compelled to subjoin a short *résumé* of the main facts.

If a mammalian, and more especially a human brain, be hardened by injecting the vessels with Müller's fluid, the appearances depicted in Fig. 447 will be seen on making a perpendicular transverse section of it. Issuing from the corpus callosum at each side is an arcuate mass of fibres (Figs. 447 and 449, C.C.T.) which turns upwards, outwards, and downwards in the midst of the centrum ovale. Let us apply the name **crossed callosal tract** to this mass of callosal fibres. Without entering too much into detail, it may be mentioned that these seem to be callosal fibres which have arisen from the cortex on one side (see Fig. 448, C, C), which have crossed the middle line in the corpus callosum, and which are now turning downwards. Notice where they go to. They split mainly into two lots. The inner of these, which is also the larger, enters the *inner capsule* (Fig. 447, I.C.), while the outer and smaller (O.C.) passes into the *outer capsule*. It may be that there is yet a third contingent (Fig. 448, C'', C'') which passes through the *lenticular nucleus* as the striæ medullares, its fibres uniting below to form the *lenticular nucleus loop*.

Those of the inner capsule end by becoming attached chiefly to the basal ganglia and parts still farther downwards. The *thalamus* receives perhaps most of them (Fig. 448, c^x), but they evidently pass down also to the gray matter of the *pons and medulla*, and it may be of the spinal cord. Those of the outer capsule become attached to various parts, and, as shown in Fig. 447, among these to the *anterior commissure*.

The sum and substance of the matter is that the corpus callosum does not seem to be a commissure in the ordinary sense, but, rather, a decussation of *certain* cortical fibres which do not decussate lower down. The author has been interpreted erroneously by certain opponents of this theory as reviving Foville's view that the corpus callosum represents the decussation of the peduncular fibres. Such was never the case. The *peduncular fibres* (*m*, *m*) descend directly and lie at the outer border of the crossed callosal tract. They are sometimes bound up with those of the tract, but more usually are quite distinct from them. They form only a small contingent of the fibres entering the inner capsule, and are most numerous in its posterior limb, where, in its anterior two-thirds, they constitute about one-third of the whole

---

[1] For refs. see Bibliog. under General Literature on Anatomy of Nervous System, p. 655.

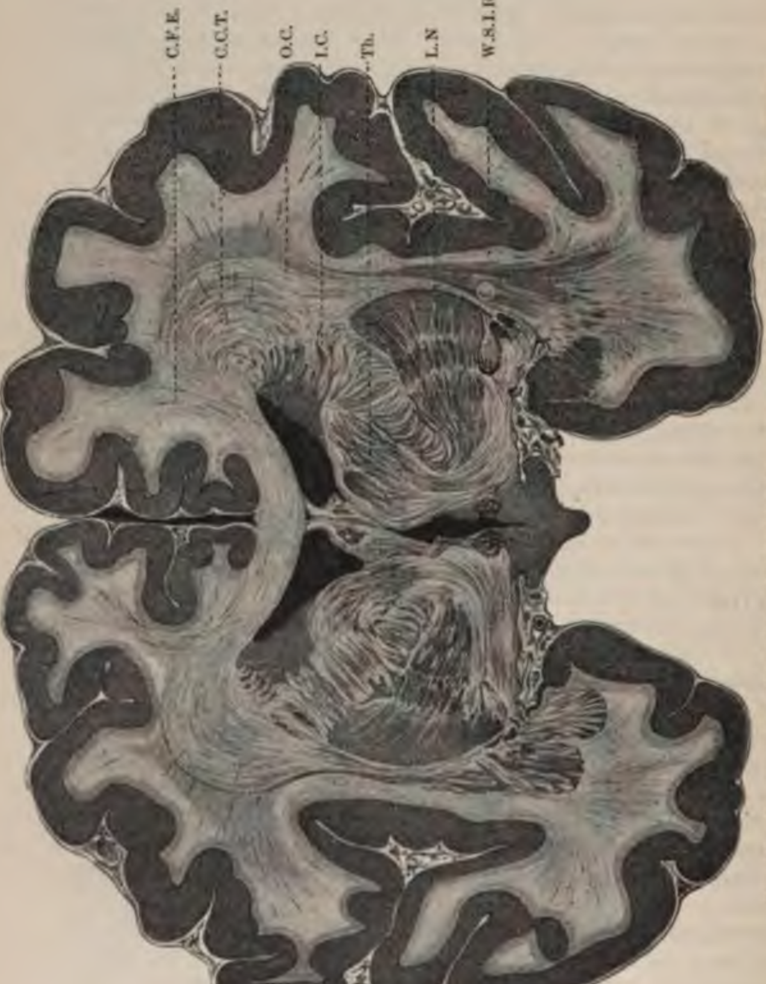


FIG. 447.—PERPENDICULAR TRANSVERSE SECTION OF CEREBRUM HARDENED IN MÜLLER'S FLUID, SHOWING THE COURSE OF THE CALLOSAL FIBRES.

They are seen entering from the vertex (C.F.E.), and turning down into the inner capsule through the crossed callosal tract (C.C.T.) (O.C.) Fibres of crossed callosal tract running into outer capsule; (I.C.) fibres of crossed callosal tract running into inner capsule; (Th.) thalamus; (L.N.) lenticular nucleus; (W.S.I.R.) white substance of island of Reil uniting operculum and temporo-sphenoidal lobe.

mass. In the anterior limb they are much less numerous, the greater bulk of this being made up of crossed callosal fibres.

The turning downwards of the corpus callosum can be seen very well in the *four months' human* embryo. The pyramidal fibres lie outside of the crossed callosal tract as in the adult, and the callosal fibres split to enter the inner and outer capsules.

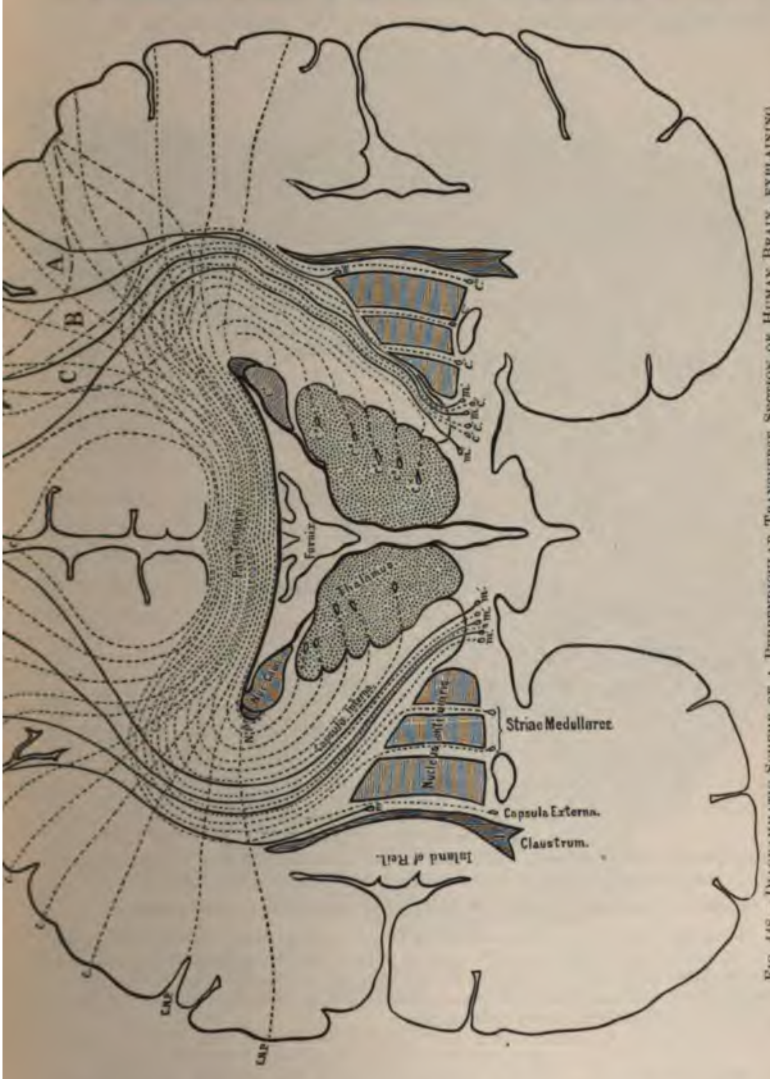


FIG. 448.—DIAGRAMMATIC SCHEME OF A PERPENDICULAR TRANSVERSE SECTION OF HUMAN BRAIN, EXPLAINING THE AUTHOR'S VIEW OF THE CORPUS CALLOSUM.

(c, c, c) Callosal fibres passing into the *pars tectoria* of the corpus callosum, and curving downwards on the opposite side into the *internal capsule*, *striæ medullares* (c'', c''), and outer capsule (c''', c'''). Those entering the inner capsule are distributed to the caudate nucleus (c^o), thalamus (c^x), and to the pons and medulla (c'). At CNP are represented the cortical fibres connected with the nucleus plexiformis (NP); the motor and other direct fibres are shown at m, m, m, running directly into the inner (m', m', m'), and probably into the outer capsule (m''). They are continued downwards to the medulla and cord. The dotted lines A, B, and C show the effects of lesions of the cortex at various depths. In A the motor fibres m', m', m', and the corresponding fibres about to cross, would be involved; in B the lesion would, in addition, destroy certain of the callosal fibres which have already crossed; while in C nearly the whole of the latter would suffer.

In the *brain of an idiot* examined by the author, where a great part of the frontal lobe had been destroyed and where the vacuity was in a state of porencephalia, the crossed callosal and peduncular tracts were found beautifully dissected out. A drawing of a section of this brain is given in Fig. 452, where it will be observed that the porencephalous condition of the hemisphere has opened out the various tracts of fibres in the neighbourhood. Those concerned with the corpus callosum are revealed in a particularly diagrammatic manner. The chief leash of fibres entering it and about to cross (C. F. E.), namely, that derived from the vertex, the **crossed callosal tract** (C. C. T.), or those leaving it and turning down to enter the inner capsule (I. C.) after

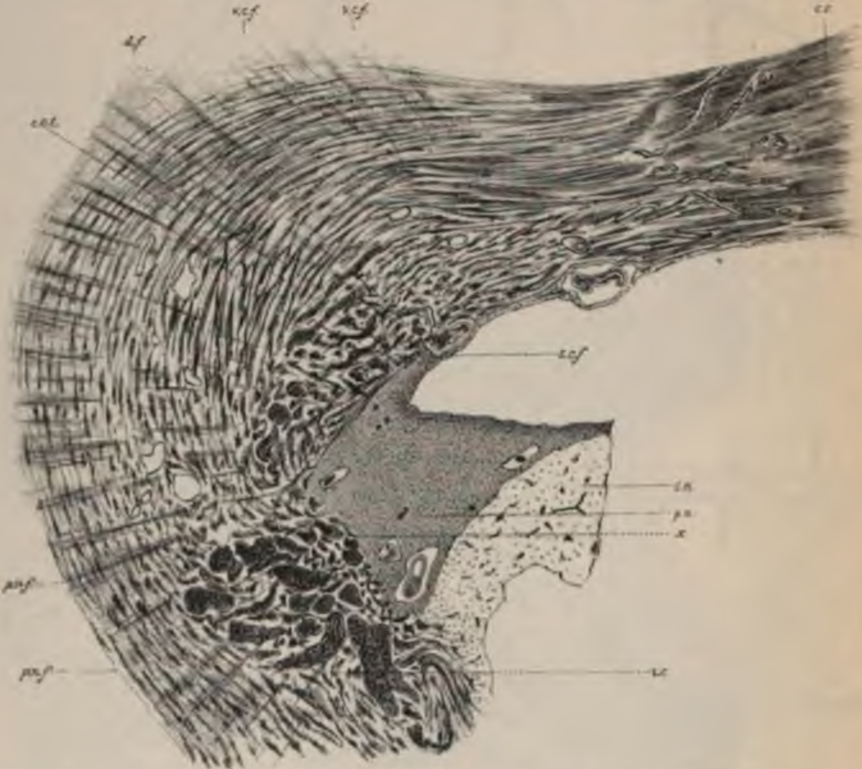


FIG. 449.—PERPENDICULAR OBLIQUE ANTERO-POSTERIOR SECTION OF HUMAN BRAIN THROUGH THE CORPUS CALLOSUM AND CROSSED CALLOSAL TRACT (×10-20 DIAMS.)

Stained by the author's modification of Weigert's copper-hæmatoxylene process.

(*c.c.*) Corpus callosum; (*c.c.t.*) crossed callosal tract; (*v.c.f.*, *v.c.f.*) callosal fibres from the vertex; (*p.n.f.*, *p.n.f.*) same, from cortex lower down, running towards the plexiform nucleus (*p.n.*); (*d.f.*) direct cortical fibres lying outside the crossed callosal tract, and running down to the inner capsule (*i.c.*); (*s.c.f.*) severed callosal fibres of the crossed callosal tract; (*c.n.*) caudate nucleus; (*x*) boundary line between plexiform nucleus and inner capsule.

having crossed, and the direct descending fibres (D. D. F.) are all well displayed.

In certain mammalian types the connections of the corpus callosum, owing to the simplicity of the structure of the organ, can be readily made out. Their examination supports the view just enunciated of its nature. In the edentata the appearances are particularly graphic. Rabl-Rückhard (No. 14, xxxv. 1890, p. 165) some time since drew attention to the correspondence of the corpus callosum in the armadillo (*Xenurus gymnurus*) with what was described by the author. Two drawings illustrating this paper are reproduced in Figs. 450 and 451. If they are compared with Fig. 447 the resemblance will be found to be noteworthy. The corpus callosum (Fig. 451, *tr.*) turns

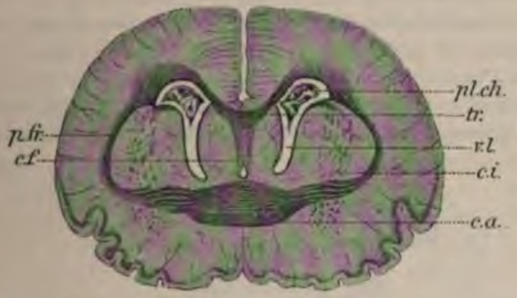


FIG. 450.—SECTION OF BRAIN OF XENURUS GYMNURUS THROUGH THE ANTERIOR COMMISSURE, SHOWING THE CORPUS CALLOSUM TURNING DOWN INTO THE OUTER CAPSULE. Magnified three times. (After Rabl-Rückhard.)

(*p.fr.*) Outer capsule; (*c.f.*) columnæ fornicis; (*pl.ch.*) plexus choroidei; (*tr.*) corpus callosum; (*v.l.*) lateral ventricle; (*c.i.*) inner capsule; (*c.a.*) anterior commissure.

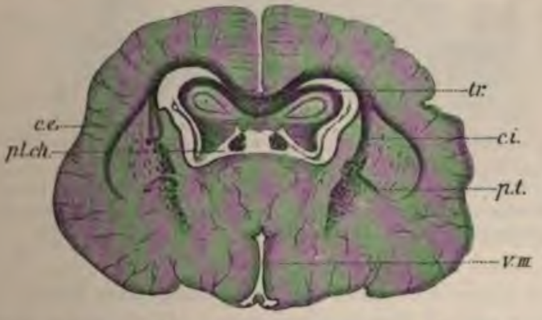


FIG. 451.—SECTION OF BRAIN OF XENURUS GYMNURUS, SHOWING THE CORPUS CALLOSUM TURNING DOWN INTO THE INNER AND OUTER CAPSULES. Magnified three times. (After Rabl-Rückhard.)

(*c.e.*) Outer capsule; (*pl.ch.*) choroid plexus; (*tr.*) corpus callosum; (*c.i.*) inner capsule; (*p.t.*) pars temporalis of anterior commissure; (V. III.) third ventricle.

downwards and splits into the inner (*c.i.*) and outer (*c.e.*) capsules exactly as it does in Man. The outer capsule is very large in these types, and as displayed in Fig. 450, joins the anterior commissure (*c.a.*) below. This connection has long been known to the author, and is represented in Fig. 440 taken from Man.

There is considerable difficulty in tracing the course of the callosal fibres by means of **secondary degeneration.** They do not react so readily as the peduncular fibres do. Whether or not this is owing to their having trophic centres in the thalamus and other parts to which they become attached, cannot possibly be answered at present.

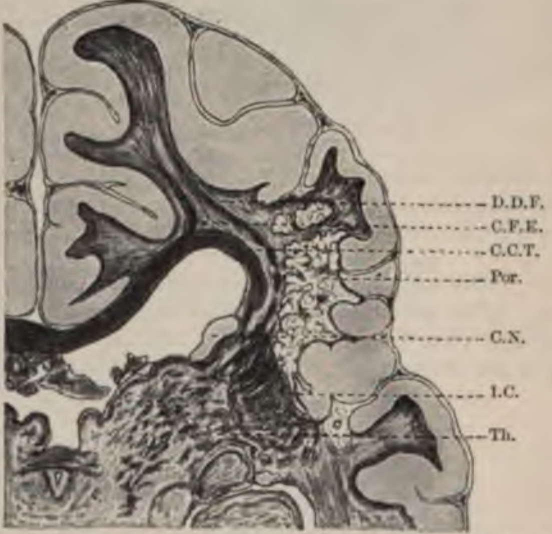


FIG. 452.—PORENCEPHALIA AFFECTING LATERAL ASPECT OF CEREBRUM (Natural Size).

(D.D.F.) Direct descending fibres; (C.F.E.) fibres entering corpus callosum from vertex; (C.C.T.) crossed callosal tract, consisting of those fibres which have crossed in the corpus callosum, and which are descending in the inner capsule; (Por.) porencephalous destruction; (C.N.) caudate nucleus; (I.C.) inner capsule; (Th.) thalamus opticus (gelatine-potash method).

Sherrington states that some time after destructive lesions of the cord area, or that area of the cerebral cortex giving origin to the peduncular fibres and other parts of the cortex, he could trace a secondary degeneration running across the corpus callosum into the opposite hemisphere. Murotoff (No. 51, 1893, Anat. Ab., p. 97) makes a similar assertion. In neither case, however, is the assertion supported by a clear view of how much of, to what depth, the hemisphere was cut into. This is the *crux* of the whole matter as will be seen by looking at the scheme depicted in Fig. 448. There is good reason for believing that the trophic centres for the callosal fibres may be *below*, not *above*; and, accordingly, if the lesion of the hemisphere occupied the area A, only those fibres going to the opposite side would be divided. If, however, the destruction involved the area B, those which are about to cross and some of those which have already crossed would be cut across. While, if it proceeded as far as the area C, a much larger proportion of those which have already crossed would be divided. These presumably have their trophic centres below, and hence might degenerate upwards into the opposite hemisphere.

Experimental evidence of the course of the callosal fibres, derived from a knowledge of their function, is unfortunately meagre. The older methods of operating by way of section of the corpus callosum, such as those practised by Saucerotte, Longet, Magendie, Flourens, etc., have revealed little of a positive nature, and even in later times those of Koranyi (No. 169, xlvii. 1890, p. 35) in dogs were not in any way more worthy of note. The animals remained, it is said, in possession of all their functions. Mott and Schaefer (No. 6, 1890, i. p. 1124; *also*, No. 521, xiii. 1890, p. 174) emphasise that stimulation of the corpus callosum in the monkey by weak induction currents produces localised bilateral movements in all parts of the body, the muscles which respond to the stimulus depending upon the position of the electrodes. Thus, anteriorly, head and eye movements were obtained, but never face movements. A little farther back movement of the shoulder muscles on both sides occurs. Still farther back well-marked movements of the trunk muscles were obtained; while leg and tail movements followed upon stimulation still posterior to this. All the movements were bilateral and fairly equal on both sides.

When the corpus callosum is divided by removing one hemisphere, the callosal fibres, cut across, are exposed as they enter the opposite hemisphere. If these are stimulated by an extremely weak current, localised movements, they allege, occur on the side of the body opposite to that with which the stimulated fibres are still connected. The portion from which movements can be called forth, they say, is limited to the thin middle part of the corpus callosum. The order in which the movements of the respective muscles manifest themselves is the same as before, namely, the eye movements most anteriorly, head and shoulder movements next, and most posteriorly those of the trunk, tail, and legs.

These results might quite well be accounted for by the view just enunciated that the corpus callosum is in reality a decussation of fibres arising from nerve cells in each hemisphere; and that after decussating these fibres run, not into cells in the opposite hemisphere, but directly downwards into the inner capsule and parts below. It is doubtful whether the callosal fibres function in a direction downwards. More probably impulses pass along them from the lower centres to the higher. As the author has expressed it, they are probably the means of educating the motor cortex—the means of conveying impulses to arouse the motor area of the brain. Hence if the corpus callosum is divided as in the above experiment, contractions on the *same side* of the body as that from which the cerebral hemisphere has been removed might only be expected. Say that the *right* hemisphere is excised. The stimulus of the applied electrodes is conveyed up to the *left* hemisphere, whose motor nerve cells are aroused. Contraction follows consequently in the muscles on the right side.

Literature on Diseased Conditions of the Corpus Callosum, bearing upon its Connections and Function.—**D'Alloco** (Glioma Affecting): Riv. clin. e terap, Naples, xi. 1889, p. 169. **Anton:** Zeitschr. f. Heilk., vii. 1886, p. 53; *also*, other references in same. **Berkley** (Tumour): Am. Journ. Ment. Sc., Phila., xcix. 1890, p. 578. **Bruce** (Absence): Proc. Roy. Soc., Edin., xv.; *also*, Rep. Lab. Roy. Coll. Phys., Edin., i. 1889, p. 70. **Bruns** (Tumours of): Berl. klin. Wochnschr., xxiii. 1886, pp. 340, 364. **Eichler** (Defect): Arch. f. Psychiat., viii. 1878, p. 355. **Hamilton** (see Refs. under General Literature on Anatomy of Nervous System, p. 655). **Jelgersma** (Brain without C. C.): Neurol. Centralbl., ix. 1890, p. 162. **Korányi** (Effect of Division): Arch. f. d. ges. Physiol., xlvii. 1890, p. 35. **Meyer** (Secondary Degenerations of Isthmus of Encephalon): Mém. Soc. de méd. de Strasb., xxii. 1884-85, p. 145. **Onufrowicz:** Das balkenlose Mikrocephalengehirn Hofman, 1887; *also* (Absence of), Arch. f. Psychiat., xviii. 1887, p. 305. **Paget** (Defect): Med.-Chir. Trans., xxix. 1846, p. 55. **Petrove** (Rare Deposit of Fat along): Boll. d. r. Accad. med.-chir. di Napoli, 1889, i. p. 163. **Pollák** (Partial Deficiency): Arch. f. Psychiat., xii. 1881, p. 157. **Reinhard** (Funct. of Corp. Call. illustr. by a Lesion): Centralbl. f. Nervenheilk., viii. 1885, p. 49. **Sander** (Defect): Arch. f. Psychiat., i. p. 135. **Schaad:** Ein Fall von Gliom des Corpus callosum, 1888. **Schrœter** (Abnormally Short): Allg. Ztschr. f. Psychiat., xliv. 1888, p. 408. **Urquhart** (Defect): Brain, 1880.

Question of Direct Course of Pyramidal Fibres.

From the results of experiments made upon the cortex it is evident that the pyramidal fibres are derived from a wide area, so wide that it is a question difficult to answer how it is that they become so concentrated at the point of decussation in the pyramids. The general notion at the present day is that the fibres issuing from the cells of the cortex in the area from which they are derived pass continuously and without interruption into the spinal cord. This is open to question, for interweaving itself throughout the cortex of the cerebrum and cerebellum there is a dense plexus of nerve fibres apart from those fibres directly issuing from the nerve cells. It was described by Butzke, Boll, Gerlach, Rindfleisch, and more especially by Exner (No. 12, lxxxiii. Ab. III. H. 1-5, 1881, p. 151), and is seen only when stained by particular methods.

This plexus, however, is not confined to the cortex of the cerebrum. It is continued inwards and twines itself around the nerve fibres throughout a great part of the white matter. The large medullated nerve fibres from the cortex run into the white matter, and become surrounded almost immediately by a dense padding of this nerve network. The cortical plexus is a mere outcrop of this. The appearance presented by it in the centrum ovale a short way within the cortical gray is very remarkable. Between the fibres and filling its meshes is the granular neuroglia.

It seems likely, as Hill suggests, that, since the discovery of this plexus, our whole notions of what are known as *nerve centres*, and of the communication that exists between nerve cells and fibres, will shortly be revolutionised.

One of the possible functions exercised by it may possibly be that of effecting an intercommunication between nerve fibres issuing from the cortex. We may well suppose it to be an agent of *reduction and association*, a means whereby the action of the many fibres coming from a particular cortical area may be combined and correlated in the few.

We can thus understand how it comes about that the pyramidal fibres are contracted to so slender a band when they reach the medulla oblongata and cord.

PROBABLE ORIGIN AND MEANING OF THE SO-CALLED COMMISSURES AND OTHER WHITE TRACTS OF THE BRAIN.

927. It is a remarkable fact that the chief white tracts of the cerebrum maintain a ring-like arrangement round its ventricular system (Fig. 445, III. V.). Thus commencing in front there is the genu of the corpus callosum, with its two pointed extremities abutting upon the anterior commissure; below this the anterior commissure (Fig. 444, A. C.). Laterally there is the outer capsule (O. C.) continued into the parieto-occipital band (P. O. B.). The parieto-occipital band again, it will be noticed, circumvents the tip of the posterior horn of the ventricle (Fig. 445), and is continued directly into the splenium of the corpus callosum (C. C.). The ventricular system is thus enveloped in a continuous ring of white matter, to which also probably belongs the posterior commissure.

The ventricular cavity of the brain is admitted on most hands to be a remnant of the invertebrate alimentary canal. Whether it has originally been an œsophagus or a stomach, a stomach of crustacean type, need not engage us at present. The probability is that it represents what was originally the anterior extremity of the digestive tract.

In accordance with this it comes to be a question whether the entire commissural system and its adnexa above enumerated, forming as they do a ventricular ring, do not correspond simply to the œsophageal ring or rings of the invertebrate, some parts of the ring being much evolved, others sunk into comparative insignificance.

Taking this view of the matter, the two inner capsules and the cerebral peduncles would represent the commencement of the invertebrate double ganglionated cord, the spinal cord the same continued backwards. The cortex of the cerebrum and basal ganglia would, under such circumstances, be the analogues of the gray ganglia attached to the invertebrate ring.

It is of course impossible in a work such as the present to adduce evidence bearing upon this theory. It may be remarked, however, that the author has never seen *a commissure* in the ordinary acceptation of the term in any part of the central nervous system, and is sceptical of the existence of such a structure. The combined action of the two halves of the body where it exists, as in the case of the cranial nerves, seems to be attained certainly by decussation of tracts of fibres, but not by the union of corresponding nerve cells on opposite sides of the nervous axis. The facts of aphasia, indeed, seem to point to the conclusion that many of the most important functions of the brain are controlled from one side only.

General Literature on Anatomy of Nervous System.

Adamük (Optic Chiasma): Arch. f. Ophth., xxvi. 2 Ab., 1880, p. 187. **Aeby:** Schema des Faserverlaufs im mensch. Gehirn u. Rückenmark, 1885. **Auerbach** (Antero-lateral Column of Cord): Arch. f. path. Anat., cxxi. 1890, p. 199. **Balighian** (Crossing of Motor Tracts): Beitr. zu Anat. u. Physiol. (Eckhard), Giessen, viii. 1878, p. 193. **Bechterew** (Optic Chiasma): Neurol. Centralbl., 1883, ii. p. 53; (Course of Optic from Corp. Quad.) Neurol. Centralblatt, 1883, ii. p. 265; *also* (Cerebellar Peduncles), Neurolog. Centralbl., iv. 1885, p. 121; *also* (New Connection between Great Olive and Cerebral Cortex), Neurol. Centralbl., iv. 1885, p. 194; *also* (Corp. Restiformia), Arch. f. Anat. u. Entwicklngsgesch., 1886, p. 403; *also* (P. Columns of Sp. Cord), Arch. f. Anat. u. Entwicklngsgesch., 1887, p. 126. **Beevor** (Hamilton's Theory of Corp. Call.): Brain, viii. 1885-86, p. 377; *also*, ix. 1886-87, p. 63. **Bellonci** (Central Termination of Optic): Arch. ital. de biol., vi. 1884-85, p. 405. **Borgherini:** Beitr. z. Kennt. d. Leitungsbahnen im Rückenmarke, 1886; *also*, Mitth. a. d. Inst. f. allg. u. exper. Path. d. Wien. Univ. **Broadbent** (Struct. of Cerebral Hemisphere): Journ. Ment. Sc., xvi. 1870-71, p. 1; *also* (Construct. of Nerv. Syst.), Brit. Med. Journ., 1876, i. pp. 371, 401, 433. **Bruce** (Connections of Lower Olive): Rep. Lab. Roy. Coll. Phys., Edinb., 1890, ii. p. 248; *also*, Illustrations of Nerve Tracts in Mid and Hind Brain, 1892. **Dalton:** Topographical Anat. of Brain, 1885; *also*, Brain, iii. 1880-81, p. 145. **v. Darkschewitsch** (Post. Comm.): Neurol. Centralbl., iii. 1885, p. 100; *also* (Corp. Quad.), Neurol. Centralbl., iv. 1885, p. 251; *also* (Upper Nucleus of Oculo-Motor), Arch. f. Anat. u. Entwicklngsgesch., 1889, p. 107. **Dreschfeld** (Course of Optic in Brain): Brain, iv. 1881, p. 542. **Eberstaller:** Das Stirnhirn, 1890. **Edinger** (Course of Post. Col. of Cord in Med. Ob. and in Lower Cerebell. Peduncle): Neurol. Centralbl., iii. 1885, p. 73; *also* (Importance of Corp. Striat. and Basal Optic Nerve Root), *Transl.*, Journ. Nerv. and Ment. Dis., N. Y., xiv. 1887, p. 674; *also*, Vorlesungen üb. d. Bau d. nervösen Centralorgane, 1885; *also* (Origin of Acusticus and Direct Sensory Cerebellar Tract), Arch. f. Psychiat., xviii. v. 1887, p. 272. **Erlitzki** (Acusticus, Structure): Arch. de neurol., iii. 1882, p. 36. **Flatau** (Connection between Nasal Lymphatics and Sub-Arachnoid Space): Deut. med. Wochnschr., xvi. 1890, p. 972. **Flechsig:** Die Leitungsbahnen im Gehirn u. Rückenmark, 1876; *also* (Connection between P. Cols. and Brain), Neurol. Centralbl., iii. 1885, p. 97. **Flower:** Schematic Atlas of the Nervous System. **Forel** (Anat. of Brain): Arch. f. Psychiat., xviii. 1887, p. 162. **Foville:** Traité complet de l'anat. . . . du syst. nerv. (with atlas), 1844. **Fraser:** A Guide to the Operations on the Brain, 1890. **Frenkel** (Nerve Terminations in Epithelium): Arch. f. path. Anat., cix. 1887, p. 424. **Freud** (Intermediate Olivary Layer): Neurol. Centralbl., iv. 1885, p. 268. **Gad:** Einiges über Centren u. Leitungsbahnen im Rückenmark, etc., 1884. **Ganser** (Course of Optic): Arch. f. Psychiat., xiii. 1882, p. 341. **Gaskell** (Cranial Nerves): Journ. of Physiol., x. 1889, p. 153. **Gierke** (Connect. Tissue of Cent. Nerv. Syst.): Arch. f. mik. Anat., xxv. 1885-86, p. 441; *also*, *Ibid.* (Connect. Tissue of Centr. Nerv. Syst.): Arch. f. mik. Anat., xxvi. 1885-86, p. 129. **Golgi** (Finer Structure of Sp. Cord): Anat. Anzeig., v. 1890, pp. 372, 443. **Gombault** (Neuroglia): Arch. de physiol. norm. et path., v. 1873, p. 458. **Gowers** (Path. Evidence of Incomplete Decussation of Optic):

Centralbl. f. d. med. Wissensch., xvi. 1878, p. 562. **Gratiolet** (Expansion of Optic): Arch. d'Ophth., iv. 1855, p. 5. **Gruenhagen** (Endothelium of Primitive Nerve Sheath): Arch. f. mik. Anat., xxiii. 1883-84, p. 380. **v. Gudden** (an Undescribed Tract): Arch. f. Psychiat., ii. 1870, p. 364; *also* (Optic Chiasma), Arch. f. Ophth., xx. 1874, 2 Ab., p. 249; *Ibid.*, xxi. 1875, 3 Ab., p. 199; *Ibid.*, xxv. 1879, 1 Ab., p. 1, 4 Ab., p. 237; *also* (Corp. Mamm. and Fornix), Arch. f. Psychiat., xvi. 1885, p. 564. **Hamilton** (Connections of Optic): Proc. Roy. Soc. Lond., xxxvii. 1884, p. 1; *also* (Corp. Call. in Adult Human Brain): Journ. Anat. and Physiol., xix. 1884-85, p. 385; *also* (Corp. Call. in Embryo), Brain, viii. 1885-86, p. 145; *also* (Structure and Connections of Corpus Callosum), Proc. Royal Soc. Lond., No. 230, 1884, p. 349; Liverp. M.-Chir. Journ., vi. 1886, p. 3; Med. Press and Circ., xli. 1886, p. 113; *also* (Large Sections of Brain), Brit. Med. Journ., 1886, ii. p. 764; *also* (Conducting Paths between High and Low Centres), Proc. Roy. Soc. Edin., xiv. 1888, p. 519; *also*, Brit. Med. Journ., 1887, i. p. 493. **Heitzmann** (Minute Structure of Gray Nerve-Tissue): Journ. Nerv. and Ment. Dis., N. Y., xvii. 1890, p. 357. **Hill**: Plan of Central Nerv. Syst., 1885; *also* (Grouping of Cranial Nerves), Brain, x. 1887-88, p. 422. **His** (Development of First Nerve Tracts): Arch. f. Anat. u. Entwicklngsgesch., 1887, p. 368. **Huguenin**: Allg. Path. d. Krankheiten d. Nervensyst., Part I. 1873, Anatomy. **Jelgersma** (Corpus Callosum and Convolutions): Psychiat. Bl. Dordrecht, viii. 1890, p. 691. **Kéraval and Taragoula** (Amyelinic Fibres of Brain): Ann. méd.-psych., xii. 1890, p. 268. **Key and Retzius**: Studien in d. Anat. d. Nervensystems, etc., 1875-76. **v. Lenhossék** (Course of Post. Roots of Spinal Cord): Arch. f. mik. Anat., xxxiv. 1889-90, p. 157. **Lœwe** (Connect. Tissue): Arch. f. Psychiat., vii. 1876, p. 1. **Luys**: Leçons sur la structure et les maladies du système nerveux, 1875. **Magnan and Hayem** (Connect. Tissue): Journ. de l'anat. et physiol., iv. 1867, p. 107. **Marchi** (Minute Struct. of Corp. Striat. and Thal. Opt.): Riv. Sper. di freniat., Reggio-Emilia, xii. 1886, p. 285. **Marshall** (Segmental Value of Cranial Nerves): Stud. Biol. Lab. Owens Coll., Manch., 1886, i. p. 125. **Martin** (Neuroblasts of Oculo-Motorius and Trochlearis): Anat. Anzeig., v. 1890, p. 530. **Mihalkowics** (Development of Corp. Call. and Fornix): Centralbl. f. d. med. Wissensch., xiv. 1876, p. 337. **v. Monakow** (Central Connections of Optic): Arch. f. Physiol., 1885, p. 329; *also* (Fillet), Neurol. Centralbl., iv. 1885, p. 265; *also* (Striæ Acusticæ, etc.), Arch. f. Psychiat., xxii. 1890, p. 1. **Mott** (Clarke's Column): Journ. Anat. and Physiol., xxii. 1887-88, p. 479. **Nicati** (Optic N. Fibres): Arch. d. physiol. norm. et path., ii. 1875, p. 521. **Obersteiner**: Anatomy of Central Nervous System, *Transl.* by Hill, 1890. **Onufrowicz** (Acusticus Origin—Experimental): Arch. f. Psychiat., xvi. 1885, p. 711. **Popoff** (Origin of Ant. Comm. in Cerebral Cortex): Neurol. Centralbl., v. 1886, p. 521. **Ranney**: Applied Anat. of Nerv. Syst., 1881. **Ranvier** (Neuroglia): Arch. de physiol. norm. et path., i. 1883, p. 177. **Raymond and Artaud** (Connection between Third Frontal and Island of Reil): Arch. de Neurol., 1884, p. 147. **Rohon**: Zur Anat. d. Hirnwindungen hei d. Primaten, 1884; *also*, Bau u. Verrichtungen d. Gehirns, 1887. **Ross** (Structure and Function): Med. Times and Gaz., 1877, ii. p. 457 *et seq.*; 1878, i. p. 33 *et seq.*; ii. p. 97 *et seq.* **Schiefferdecker** (Struct. of Nerv. Syst.): Arch. f. mik. Anat., xxx. 1887, p. 435; *Ibid.*, xxxi. 1887-88, p. 100. **Schwalbe**: Lehrbuch d. Neurologie (Hoffmann's Lehrbuch d. Anat.), 1881. **Spencer** (Pineal Eye of Lacertilia): Quart. Journ. Mic. Sc., xxvii. 1886-87, p. 165. **Spitzka** (Corp. Quad.): N. Y. Med. Rec., xvii. 1880, p. 282; *also* (P. Commissure), Alienist and Neurol., St. Louis, vi. 1885, p. 225; *also* (Decussation of Pyramids), Journ. Nerv. and Ment. Dis., N. Y., xi. 1886, p. 727. **Starr** (Intra-Cerebral Tracts): N. Y. Med. Rec., xxix. 1886, p. 174. **Stilling** (Optic Chiasma): Arch. f. Psychiat., xi. 1880, p. 274; *also* (Central Ending), Arch. f. mik. Anat., xviii. 1880, p. 468. **Surbled**: Le cerveau, 1890. **Sutton (J. B.)** (Relation of Nerv. Syst. to Aliment. Canal): Brain, x. 1887-88, p. 429. **Tuke** (Normal Histology): Edin. Med. Journ., xx. 1874, p. 389. **Turner** (Convolutions): Edin. Med. Journ., xi. 1866, p. 1105; (Same) West Riding Asylum Rep., iii. 1873, p. 1; (Same) Journ. Anat. and Physiol., viii. 1873, p. 142; 1874, p. 359; *also* (Convolutions), Journ. Anat. and Physiol., xxv. 1890, p. 105. **Vejas** (Connection between Cerebellum and Fun. Graciles): Arch. f. Psychiat., xvi. 1885, p. 200. **Vossius** (Optic): Arch. f. Ophth., xxix. 1883, 4 Ab., p. 119. **Whitaker**: Anatomy of the Brain, 1887. **Wollaston** (Semi-Decussation of Optic): Phil. Trans., 1824, p. 222. **Witkowski** (Neuroglia): Arch. de physiol. norm. et path., xiv. 1883, p. 155.

CHAPTER LXXXI

THE NERVOUS SYSTEM—*Continued*

APHASIA (*ἀφασία, speechlessness*).

Explanation of Terms.

928. THE term **aphasia** (Trousseau) is nowadays mostly applied in a generic sense to express partial or complete loss of the power of speech from a brain lesion. Where the loss of speech is due to peripheral causes this term is not employed. Broca used that of **aphemia** in very much the same sense. The loss of speech may be due to what Ross (No. 532, p. 5) called the *emissive* department of the speech mechanism, or to what he designated the *apperceptive* side of this mechanism. The former is motor, and is usually regarded as being caused by inability to co-ordinate the lingual muscles for the production of articulate sounds; it is known, consequently, as **ataxic aphasia.** The latter is sensory, and to it the designation of **amnesic aphasia** is often applied. Although in many cases these two forms of speechlessness occur separately, yet they may be combined.

Amnesic aphasia, however, is a term expressing a very complex group of phenomena, the chief of which are the following:—

(1) **Loss of the memory of names,** more particularly ordinary nouns and proper names.

(2) **Paraphasia,** or the condition in which the wrong word is unconsciously employed.

(3) **Word-blindness,** where the individual has forgotten the meaning of written or printed symbols.

(4) **Word-deafness,** in which the person fails to understand spoken language.

The term **agraphia** is employed to express loss of the power of writing. That of **paragraphia** has the same relative significance as paraphasia. Fleury applied the word **aphthongia** to a form of aphasia characterised by spasm of the muscles supplied by the hypoglossal nerve whenever the person tries to speak. **Alalia** is an old term not now used, and which had very much the same significance as aphasia. **Amimia** and **paramimia** are employed to express respectively loss and impairment of intellectual pantomime; **alexia** and **paralexia** loss and impairment respectively of the power of reading aloud.

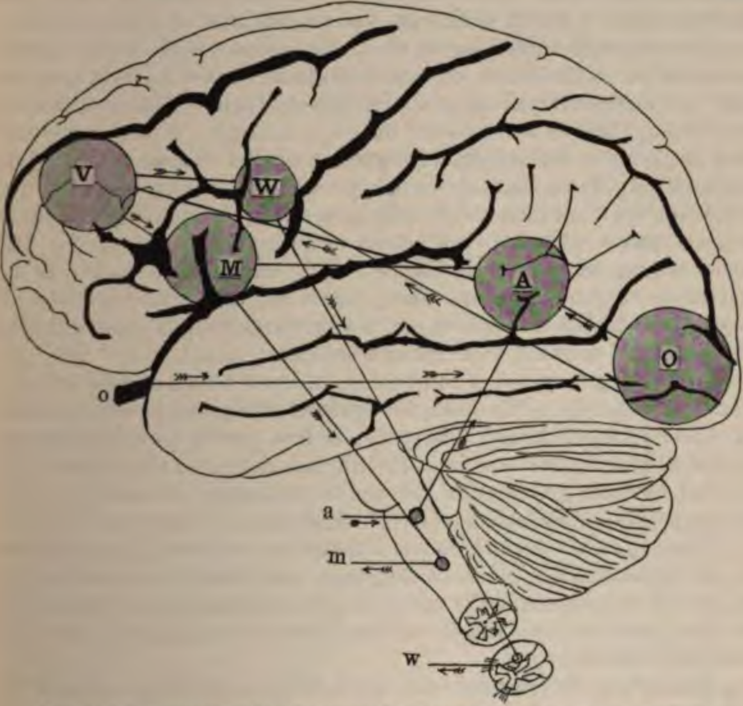


FIG. 453.—DIAGRAMMATIC SCHEME OF THE MECHANISM OF SPEECH AND OF APHASIC CONDITIONS.

(M) Motor speech area leading down to motor nerve nucleus in medulla oblongata and efferent motor nerve (*m*); (*a*) acoustic nerve leading up to acoustic nucleus in medulla oblongata, and to the acoustic area (A) in the first temporal convolution; (W) writing area communicating with the motor nucleus in the medulla oblongata, and with writing nerve (*w*); (V) volitional area communicating with the writing (W) and speaking areas (M); (A) acoustic area communicating with the volitional area (V), and with the speech area (M); (*o*) optic nerve communicating with the optic area (O) in occipital lobe; (O) optic area communicating with the acoustic area (A) on the one hand and the writing area (W) on the other.

Finally, by **asemasia** is understood loss of the power of communicating thought by speech, writing, or pantomime.

THE PHYSICAL BASIS OF SPEECH.

929. Through the repeated stimulation of the nerves of sight, hearing, touch, etc., a particular condition of the cerebral cortex in relation with each of these nerves is at last brought about. The con-

dition of the cortex manifests itself functionally as a mental residuum or memory of these various impressions. Thus we become mindful through the sense of vision that an object such as a bell has a particular shape, that it possesses a movable tongue, etc.; through the auditory channels that, when set in motion, it emits a particular sound; and through those of touch that it has certain qualities of hardness, etc.

The separate memories of the impressions acquired through the senses, however, in course of time become correlated in such a manner that we cannot think, say, of the object "bell" without insensibly associating them in a compound image or concept. There must therefore be a close commissural interunion of the various parts of the cortex where these mental residua or impressions are stored. Once obtained, the combined image may be recalled through any one of the original paths whereby the impressions have been conveyed. Thus either seeing, hearing, or feeling a bell is sufficient to excite in consciousness the notion of something which has a particular shape and structure, which when moved emits a particular sound, and which has the feeling of metallic hardness and coldness.

In learning to speak, a child comes to know that a certain articulate sound corresponds to the concept it has formed through its sense channels of this object. It learns this sound at first purely through imitation, and in course of time associates it with the concept of the object "bell." It thus becomes possessed of the auditory memory of words, or rather of the particular syllabic sounds which constitute compound words.

The centre in which these word-memories are stored must therefore be the great starting-point of language, and clinical observation tends to show that it resides in the temporo-sphenoidal lobe, more particularly in the posterior two-thirds of the first and possibly of the second temporal convolutions.

In learning to pronounce the word, the co-ordinating centre for the oro-lingual muscles has to be educated, and this is accomplished by co-ordinating for syllables first, and by the union of these afterwards into complex words. This centre corresponds to **Broca's convolution.** In the production of the *vocal part* of language, in which the larynx is largely concerned, the laryngeal centre, lying as it does close to Broca's convolution, must similarly become an educated area; and as the vocal and labial elements of voice are so intimately united, there must be a close bond of union between the two corresponding centres or areas. Any dissonance in their interaction gives rise to the condition known as **stammering.**

We have got therefore as far as having *a centre for auditory images* and *another for motor images.* Let them be represented in the accompanying scheme (Fig. 453) by the letters A and M, and let the line uniting them represent the connecting fibres.[1]

---

[1] In constructing this scheme the author begs to acknowledge his indebtedness for many suggestions to Lichtheim's paper on "Aphasia" (Original ref. No. 517, xv. 1884, p. 822; *Eng. transl.* No. 521, vii. 1885, p. 433).

As time goes on, however, the child does not require to have the object presented to it in order to recall the appropriate word. It comes to be able to do so at will. There must therefore be a higher or *volitional centre* in connection with the auditory centre on the one hand and the pronouncing centre on the other. Let V in the scheme represent this centre. Its exact localisation is mere matter of conjecture as yet, but possibly it may be widely diffused over the frontal and prefrontal regions. Those famous for command of an extensive vocabulary are usually characterised by the great development of these regions.[1]

The next step in the mental training of a child is to teach it to read. This also at first is purely imitative. The child is told that a certain symbol stands for the sound corresponding to the letter "A"; that another symbol represents "B"; and that the combination of the two forms the syllable "Ab." Further, that various syllables may be combined into complex words. In time the individual letters, and indeed the individual syllables of a complex word, lose their identity, and the symbolic representation of the whole word is what is recognised.

Now there is a pretty strong opinion at present, both in this country and abroad, that word images are perceived like other visual images; that, to put it more succinctly, the area for the perception and memory of word images is alike with that for the perception and memory of objects in the material world. And although there may be a difference of opinion as to the limits of that area, clinical experience points to the occipital lobe, or the cuneus, as being largely, if not exclusively, the seat of it. Let O in the scheme represent the centre where the memories of such symbolic representations of words are stored.

As it is entirely through hearing that their significance is learned, it follows that the storehouse for auditory memories and that for the memory of their symbolic equivalents must be in intimate relationship. We have seen previously that the auditory area in Man is located most likely towards the base of the first and possibly of the second temporal convolutions. Let the connection between it and the visual area be represented by the line uniting them in the Figure. Are there structurally any grounds for believing that such a connection actually exists?

It has been shown previously (p. 640) that through the occipito-parietal band there is an extensive connection between the occipital lobe, the temporo-sphenoidal lobe, and the island of Reil; and further, that the island is again connected to the third frontal convolution. It has, moreover, been demonstrated that the third frontal and opercular regions are extensively united with the temporo-sphenoidal by fibres which do not run horizontally as those of the occipito-parietal band do, but by others which descend through the external layer of the outer capsule and the white substance of the island. There is substantial evidence therefore to show not only that the visual centre in the occipital lobe is bound to the auditory centre in the temporo-sphenoidal, but that these further are in close relationship with Broca's convolution and the opercular region.

---

[1] Shakespeare and Sir Walter Scott were good examples of this. Out of a possible number of English words amounting to between 90,000 and 100,000, Shakespeare uses about 15,000, Milton about 8000, and an agricultural labourer about 300.

In the normal state of the brain the impression derived from the printed or written word-symbol in reading is received evidently by the occipital lobe. Thence it is transferred to the centre for auditory word-memories in the temporo-sphenoidal lobe by way of the occipito-parietal band, and therein is properly interpreted. This is evidently done by an effort of the will, for it is the experience of every one that it is possible to read without transforming the written symbols into their corresponding auditory memories, while by voluntary concentration we can overcome this. We may be conscious of the eye having seen the symbols, but their translation into language has entirely failed. The significance of the printed or written symbol seems to be perceived only when it has aroused the corresponding auditory memory. The stimulus communicated to the visual centre alone is evidently not sufficient to accomplish this. Where, so to speak, the visual impression is not shunted on to the auditory centre it is meaningless, and the individual is suffering from temporary word-blindness.

The last stage in what may be called the preparatory or fundamental education of the child is that it is taught to write. This, at first, is purely imitative, but gradually the centre for the co-ordination of the muscles concerned in writing comes to be under the control of the will.

The writing co-ordinating centre is represented in the scheme by W. It is evidently closely associated with the co-ordinating centre for speech (M), seeing that the same lesion often destroys them both. The higher connection with the will centre (V) is represented by the line joining V and W.

ATAXIC OR MOTOR APHASIA.

930. **Historical.**—Ataxic and amnesic aphasia were recognised clinically in this country by Russell and other physicians long before anything was known of their pathology. The history of their pathology commences with the year 1825, when Bouillaud[1] collected a series of cases to show that the faculty of speech resided in the frontal lobes. In the year 1836 M. Dax, in a paper read to the Medical Congress of Montpellier, stated as a result of his researches that, where speech was lost from central causes, he believed the lesion was invariably

---

[1] See Bibliog. for historical references.

found in the left cerebral hemisphere and that the accompanying paralysis of the right side of the body is consequent upon this. This

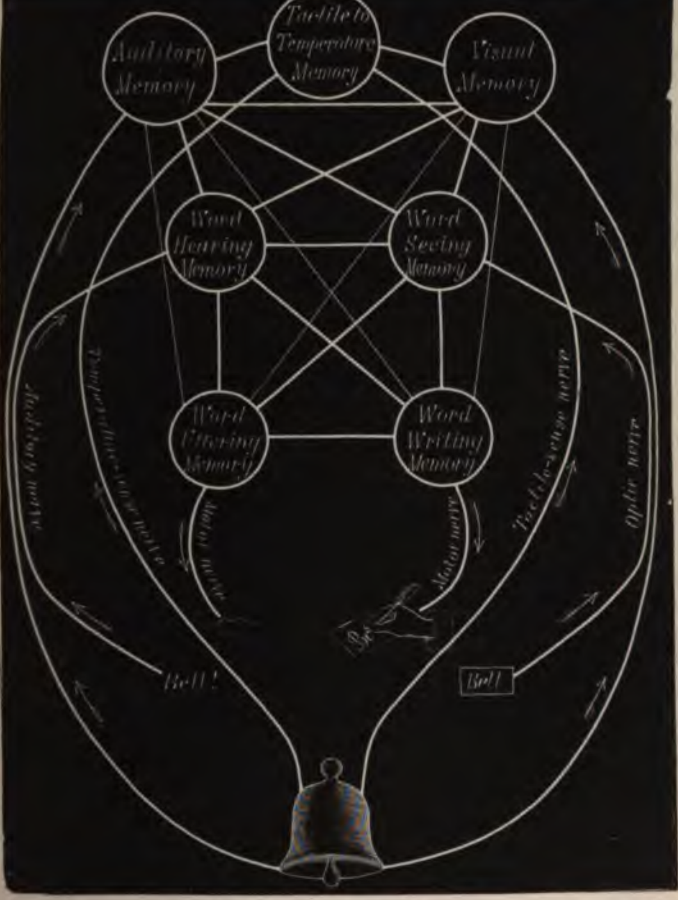


FIG. 454.—DIAGRAM TO ILLUSTRATE APHASIA, ACCORDING TO CHARCOT, MODIFIED BY STARR. THE CONCEPT "BELL."

The mental image of the bell is made up of auditory, tactile, and visual memories joined together by association. To this is added the word-image "bell," made up of the memories of the word as heard and seen, as spoken and written. Each of these memories is associated with the others, and with the memories forming the mental image. All these memories together form the concept. Such a concept has no single location. It may be destroyed by general cortical disease (as in paretic dementia). It may be impaired in parts (as in psychical blindness or some form of aphasia). It may be seriously impaired by lesions involving the association fibres. The centripetal tracts from eye and ear, and the centrifugal tracts to mouth and hand, are also shown in the diagram.

paper for long lay buried in the annals of medical literature, but was unearthed years afterwards by his son and presented to the French

Academy. Bouillaud's views were also disinterred from the oblivion they had fallen into by Auburtin, and in the year 1861 were brought by him before the notice of the Anthropological Society of Paris. Broca, who was present at the meeting, had a patient under his care at the time who had been aphasic for twenty-one years, and who was in an almost moribund state. The autopsy proved of great interest, as it was found that the lesion was confined to the left side of the brain and to what we now call the third frontal convolution. Broca was struck with the coincidence, and when a similar case came under his care some time afterwards, unaware of what had been done by Dax, he postulated the conclusion that the integrity of the third left frontal convolution and perhaps also part of the second is essential for speech. In a subsequent series of fifteen typical instances examined it was found that the lesion had destroyed, among other parts, the posterior third of the third frontal in fourteen. In the fifteenth case the destruction had taken place in the island of Reil and temporal lobe. Among the first confirmatory cases noticed in this country were those carefully annotated by Sanders, one of which happened to have implicated the island.

Broca's discovery is of particular interest not only because it served to localise the speech centre, but because it is the first instance of cortical localisation on record.

Vital Phenomena. — The individual is speechless but not necessarily wordless. Emotional words such as oaths or words which have become automatic may be retained. Sometimes the last sentence uttered by the individual at the time of the embolic or apoplectic insult is capable of being repeated. Again, meaningless syllables such as "tin-tin-a-tin" may be the only articulate sounds the person can utter. At the same time, in uncomplicated cases, the patient understands perfectly what is said to him, and may otherwise maintain the use of his mental faculties.

Ordinary thought in a healthy individual is usually accompanied by muscular contraction of some part of the body. We see this daily in the gesticulations of a person speaking excitedly and in the movements of the lips, and often unconscious utterance of articulate sounds, in deeply introspective individuals, as well as in the manifestations of so-called "thought-reading." Bain in fact takes the view that thought is in great part effected through internal speech—that is to say, by faint co-ordinate contractions, symbolic of ideas, of the articulatory muscles.

In most cases of motor aphasia this intellectual pantomime is retained. The patient makes strenuous muscular efforts to express his ideas, these being quite clearly present to him.

In some instances, however, there may be complete amimia. When this is so, more or less amnesia or sensory aphasia will be found combined with the motor defect. Indeed the two are often associated to begin with, but the sensory or ingoing phenomena afterwards disappear. The hemiplegia, as a rule, is slight in instances of pure motor aphasia. Combined sensory and motor aphasia is probably always present in cases in which the loss of speech, if persistent, is accompanied by decided hemiplegia (Ross, No. 532, p. 10).

The hemiplegia is usually a well-marked phenomenon. In the vast majority of cases it is right-sided. This is owing to embolism of the middle cerebral artery being the commonest cause of aphasia, and to the embolus, for some not very evident reason, being driven into the left vessel. The middle cerebral, it will be remembered (p. 609), supplies the third frontal convolution posteriorly, and also the greater part of the motor area of the cortex. Hence the paralysis. So severe is the effect of stoppage of the artery at its origin that death may ensue within a few hours. It is seldom, however, that this happens, the tendency being for the individual to recover from the primary effects of the obstruction. In most cases the hemiplegia, which at first may have been complete, is partially recovered from.

There are a few cases on record, such as that related by Remonat and Frebault (No. 166, No. liii. 1881), where hemiplegia has been entirely wanting. After death the chief motor centres were uninvolved in the softening which had partly destroyed the third frontal. If the injury to the third frontal be superficial, as in that caused by a spicule of bone, this is the usual result.

Motor Aphasia without Lesion.—Functional aphasia, that is to say, aphasia without any perceptible lesion, occurs after an epileptic attack or in hysterical women, sometimes in hysterical men. A complete and sometimes fatal form of aphasia without structural injury is met with in puerperal women and in others. It may be accompanied by coma and other signs of an apoplectic effusion. The brain after death is found to be free from any recognisable lesion. It is possible that this remarkable condition is to be accounted for by temporary spasm of the middle cerebral artery.

Nature of Motor Aphasia.—The disease is usually ranked along with locomotor ataxia as one of simple incoordination of the articulatory muscles. Ross, however (No. 532, p. 97), although not denying that there is an incoordination of action, traced the loss of the power of articulation to a true paralysis, and explained the incoordination in the same way as he would diplopia resulting from paralysis of certain of the oculo-motors. The accompanying hemiplegia, he says, supports this view.

Seat of Lesion.—As stated by Broca, the classical seat of the lesion is the posterior part of the third frontal convolution. The centre concerned with this form of aphasia is far more circumscribed than that for any of the amnesic varieties. As shown by experiments, this locality and the neighbouring base of the ascending frontal are, in the monkey, the parts of the cortex concerned with the movements of the tongue and lips. Exner (No. 546) says that the most intense part of the hypoglossal field in the cortex lies at the point where the second, third, and ascending frontal convolutions meet.

Thence the corresponding fibres pass backwards, according to Raymond and Artaud (No. 49, 1884), and join the knee of the inner capsule. They run down in the crus cerebri, cross the middle line, and join the hypoglossal nucleus on the floor of the fourth ventricle.

The island of Reil was found by Broca, Sanders, and Meynert to be largely implicated in certain cases. The destruction has, however, generally extended upwards towards the third frontal, and has probably cut across the fibres issuing from it.

There is, however, no authentic case on record, so far as the author is aware, where a pure and undoubted motor aphasia has resulted from a focal lesion of the inner capsule, crus, pons, or medulla, a fact which is difficult to explain and is well worthy of investigation.

Raymond and Artaud have brought forward some doubtful positive evidence on the subject. They state, however, that even in alleged instances of motor aphasia from injury to the tract and not of the centre, the power of speech is always regained. Broadbent has endeavoured to explain this coincidence through a path comparatively seldom used being opened up, namely, that running across the corpus callosum.

Anatomical Connections of the Parts concerned with Motor Aphasia.

The fibres issuing from the third frontal convolution seem to have wide connections with distant parts of the brain. Thus we saw previously (Sect. 924) that they run downwards into the temporo-sphenoidal lobe; backwards through the intermediation of the island of Reil to the occipital lobe; and forwards to curve round the ventricle, to cross in the corpus callosum, and to enter the inner capsule of the opposite side. Whether any of them pass directly backwards into the inner capsule of the same side is not quite clear. There is great difficulty in making out such a connection by any method of investigation. The direct pyramidal fibres seem to be derived mainly from the vertex and from the lateral aspect of the hemisphere for about two-thirds of its extent in a direction downwards from this. They also seem to come from the convolutions lying on the mesial aspect of the hemisphere.

Do the fibres derived from the third frontal convolution pass down continuously into the pons and medulla? It seems very doubtful if they do. The greater part of them, after entering the anterior limb of the capsule, seem to end in the large ganglia in this neighbourhood. How it is that they become connected with the nuclei of the motor glosso-labial nerves is difficult to explain, for were the connection direct and continuous, it would be expected that motor aphasia would be of common occurrence from destructive lesions in parts below the basal ganglia. We know that the opposite is the case; indeed it is doubtful if a true motor aphasia, or anything approaching to it, has ever resulted from a lesion of the pons even where both sides have been equally affected.

Bilateral Effect.—The ordinary movements of the mouth and tongue appear to be regulated from both oro-lingual centres, that of speech from only one. In right-handed individuals the left centre is apparently that which is educated for speech purposes. This at any rate is the general supposition. In persons who are left-handed the lesion has been found on the right; but Paget (No. 6, 1887, ii. p. 1258) recorded a case where right hemiplegia and motor aphasia were present in a left-handed individual, and where presumably the lesion must have been on the left side. There is a remarkable dearth of evidence, it must be confessed, as to the effects of focal destructions of the *right* third frontal convolution, owing to its being very rarely injured by embolism.

It has been suggested by H. Jackson that the mechanism for expression of oaths and other recurring utterances may be localised in the general motor centre, and be thus preserved to the individual when that for intellectual language is destroyed.

So far as known, recovery of function is never attained after the destruction of Broca's convolution in adult life. In children, on the contrary, recovery is the rule, the explanation usually afforded being that the right centre takes on the function of the left. Partial recovery of speech in the adult, however, has occasionally been noticed (B. Tuke, Fraser, Ferrier).

On turning back to Fig. 435 it will be seen that the third frontal convolution is placed peculiarly, in that it is not an isolated centre but overlies parts of importance. These are the **outer, middle,** and **inner callosal tracts** (see Sect. 924), and farther back the **conjoined band,** into which the first and second of these merge. The meaning of these tracts is as follows:—

The outer and middle are composed of the fibres which have already crossed in the corpus callosum, and, having circumvented the anterior horn of the lateral ventricle, are now turning backwards to enter the inner capsule. Before entering the capsule, however, they unite in the above-mentioned conjoined band. To this conjoined band are also superadded fibres which probably are derived from the frontal lobe of the same side, and which become united to the basal ganglia without crossing.

The inner tract is composed of the fibres of the frontal region which are about to cross in the corpus callosum, and of those which have already crossed and which are about to turn round the ventricle. The latter split into the tractus externus and medius.

It will be noticed that the gray matter of the third frontal convolution closely overlies these tracts, and it is evident, therefore, that a deep penetrating lesion of the neighbourhood of the third frontal, such as usually follows embolism or is the result of a focal hæmorrhage, would destroy not only the fibres issuing from the third frontal of the same side, but would also cut across those fibres of the same neighbourhood which have crossed in the anterior extremity of the corpus callosum. What the exact effect of this must be, seeing that we know nothing of the function of these decussating fibres, remains dubious. Whether they constitute the ordinary path for the regulation of the oro-lingual muscles in speech, or whether this path lies directly backward on the same side towards the inner capsule, remains unknown. As previously stated (p. 664), the *left* third frontal region alone seems to regulate the movements of these muscles for articulate sounds; and indeed the phenomena of sensory aphasia are also usually called forth by a left-sided lesion. Whether, however, these fibres which cross in the corpus callosum to gain the descending paths in the opposite internal capsule are bound up with the movements of the oro-lingual muscles for ordinary purposes, is well worthy of further elucidation.

AGRAPHIA (ἀ, priv., and γράφω, *I write*).

931. Pure and uncomplicated agraphia is among the rarest of morbid speech phenomena. It is usually complicated with motor aphasia and hemiplegia. One instance of pure agraphia, however, is reported by Pitres (No. 353, No. xi. 1884, p. 855). It occurred in the person of a man thirty-one years old who had previously been syphilitic. He was not blind, and did not suffer from word-deafness or word-blindness. He understood everything that was said to him. He was also free from any paralysis of the extremities. This man could draw geometrical figures, sketches of faces, etc., and he could copy manuscript, but his power of volitional writing had vanished.

Pitres distinguishes three forms of agraphia, namely—

(1) A. from word-blindness, where the individual fails to copy what is put before him.

(2) A. from word-deafness, where he fails to write to dictation.

(3) Motor agraphia or graphoplegia, in which volitional writing is lost.

The writing centre must lie very close to Broca's convolution, seeing that it is so often implicated in destruction of the latter. It is reckoned that it must be about the base of the second left frontal convolution.

Paragraphia is a still rarer affection. The individual unconsciously writes the wrong word.

AMNESIC (SENSORY) APHASIA.

932. **Historical.**—English physicians, as previously referred to, had recognised the difference between motor and sensory aphasia long before any attempt at localisation of the respective lesions. It is to Wernicke, however (No. 550), that we are indebted for the knowledge that the lesions in the two cases occupy different parts of the cerebral cortex. Kussmaul (No. 206, xiv.) generally gets the credit of

describing and naming the varieties known as "word-deafness" and "word-blindness."

Varieties.—As before mentioned, the term "amnesic aphasia" comprehends several diseased mental conditions associated with speech, namely—

(1) Loss of the memory of names.
(2) Paraphasia, or the use of wrong words unconsciously.
(3) Word-blindness.
(4) Word-deafness.

It is seldom that these occur separately. The chain which links together the various centres concerned in their production cannot be severed without deranging the whole apperceptive speech mechanism. In no case is this interdependence better exemplified than in cases of word-blindness and word-deafness.

(1) LOSS OF THE MEMORY OF WORDS (AMNESIA VERBALIS).

933. By an effort on the part of any normally-constituted individual, be it of the will or of other agency, it is possible to recall the memory of a word whose sound has once made a deep impress upon the brain. This power, as every one knows, sometimes fails temporarily, and oftenest when the brain is exhausted. It returns with the necessary rest. It is a power which apparently diminishes with old age. Its loss amounts to a truly diseased state in certain brain lesions of no very constant location. The word can in most cases be recalled by the sight of the written or printed symbols corresponding to it.

Broadbent (No. 521, i. 1879, p. 496) asserts that sometimes concrete nouns are alone forgotten, but Ross (No. 532, p. 110) doubts whether this can be so without the other parts of speech being impaired.

Broadbent (*loc. cit.*) also draws attention to a frequent variety of this affection, namely, where names are more or less remembered, but where there is loss of the faculty of constructing a sentence which shall convey the ideas to be expressed regarding them, as in the example, "Brother, brother—New York—America—two brothers in America—letter."

The site of the lesion associated with this condition is unknown.

(2) PARAPHASIA.

934. As an example of what is meant by the term, the following from a paper by Broadbent (No. 521, i. 1879, p. 487) may be taken:—The instance occurred in the person of a man who eight years previously had contracted syphilis and had become suddenly hemiplegic. He was asked to read, "You may receive a report from other sources of a supposed attack on a British Consul-General. The affair, however, is utterly unworthy of consideration. No outrage was even

intended, and the report is due to the misrepresentation of facts. The Odessa line is again working properly." It was read by the patient slowly, and in a jerky manner, as nearly as it could be taken down phonetically thus: "So sur wisjee coz wenement ap ripsy fro fruz fenement wiz ā seconce coz foz no Sophias ā thee freckled pothy conollied. This affaise eh oh cont oh curly of consequences. Uce sudos val oh es es entain ah thee enepol ā oh dee ā ah messequence oh coz foz. The assoil lens ā puff pifl miss corres povety."

Just as in most other cases, there is a certain imperfect correspondence between the number and length of the words, but otherwise no resemblance to the original.

The seat of lesion causing this peculiar state is as yet undetermined. West, however, quotes a case (No. 59, 1885, i. p. 111), combined with complete word-blindness and partial word-deafness, where the lesion was situated in the left angular and supra-marginal gyri and island of Reil, and in which Broca's convolution and the two capsules were preserved while the first temporal convolution was deeply undermined.

The term **paralexia** is sometimes applied to a condition such as the above quoted, where the paraphasia is manifested on *reading* aloud.

(3 and 4) Word-Blindness (Cæcitas verbalis), Kussmaul—Amnesie verbale visuelle; and Word-Deafness (Surditas verbalis), Kussmaul.

935. By the former of these terms is meant the loss of the power of interpreting written or printed symbols while vision is unimpaired. By the latter is indicated a loss of the power of understanding spoken language, the sense of hearing not being defective. They are frequently combined.

In the word-blind individual the meanings of printed and written symbols of speech fail to arouse the idea they are intended to convey. The subject of it may be seen poring over a newspaper or book for hours without having gained any idea of what knowledge the printed symbols convey.

In some recorded examples there was marked psychical blindness along with word-blindness—that is to say, failure to interpret the meanings of objects seen. Starr, in fact, looks upon word-blindness simply as a part of psychical blindness.

Curiously, the power of understanding figures sometimes remains, and the individual is capable of adding figures correctly together. (See case by Suckling, No. 6, 1886, i. p. 691.)

In the word-deaf individual spoken language is meaningless, although written symbols may be interpreted. Such individuals are often supposed to be deaf or mentally wanting from the unmeaning stare with which they respond to questions.

The lesions in both of these conditions have as yet always been found on the left side. In eleven instances of pure **word-blindness** collected by A. Starr (No. 521, xii. 1890, p. 86) the lesion was found to be somewhat irregularly distributed. The angular gyrus was affected in five cases, the occipital lobe in five, the temporal convolutions in three, the inferior parietal region in three, and the supramarginal gyrus in two.[1] The convolutions lying at the base of the temporo-sphenoidal lobe seem from this and other analyses to be those most frequently implicated—that is to say, the angular and supramarginal gyri, together with portions of the origins of the first and second temporals.

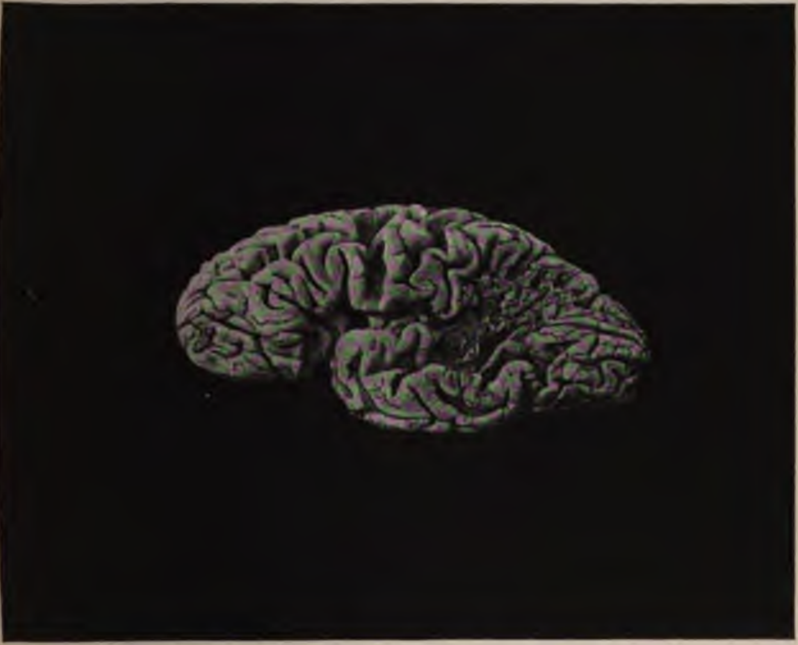


FIG. 455.—LEFT CEREBRAL HEMISPHERE FROM A CASE OF WORD-DEAFNESS SHOWING DESTRUCTION OF THE INFERIOR PARIETAL LOBULE AND POSTERIOR PART OF FIRST TEMPORAL GYRUS (Wiglesworth).

In seven examples of pure **word-deafness** collated by A. Starr (No. 521, xii. 1890, p. 86), the lesion was limited to the first and second temporal convolutions in their posterior two-thirds. From accumulated instances of the condition, the generally-accepted conclusion is that the posterior half of the first temporal convolution is that which is oftenest the seat of destruction.

---

[1] By "inferior parietal region" he means the portions of the gyri supramarginalis and angularis included between P_2 and P_2' in Ecker's side view of the cerebral hemisphere (see Fig. 427), bounded above by the interparietal sulcus and below by the first temporal sulcus.

The Mechanism of Word-Deafness and Word-Blindness.

The occipito-temporal system subservient to speech is composed essentially of four parts, namely: (1) the visual centre in the occipital lobe; (2) the auditory centre in the temporo-sphenoidal lobe; (3) the fibres of the occipito-temporal band uniting these; and (4) the peripheral apparatus (optic nerve, tract, and cerebral expansion, and auditory nerve and cerebral expansion) serving to connect the optic and auditory centres with the outer world. There are also four sets of phenomena through the perception of which a destructive lesion in these four individual parts may be localised.

If the occipital lobe on one side be destroyed, more or less **cortical blindness** will result; if on both sides the individual is **psychically blind.** In the former case, visual memories, although blunted, are not entirely forgotten, and can be aroused through channels other than the optic; in the latter, not only is the individual blind, but visual memories fail to be stimulated through any other path. Thus, in the former case (cortical blindness) there would be hemianopsia with an ill-defined separation between the dark and the illumined half of the field of vision; a pencil of light let fall on the paralysed side of the retina would still cause contraction of the pupil; and the visual memories connected with an unseen object like a bell could readily enough be aroused by sounding it. In the latter case (psychical blindness), although the pupil reflexes remain, the perception of colour and even of light has most likely gone, and, moreover, the sound or feeling of an object, say a bell, fails to arouse recollection of what that object is like.

If, on the other hand, the individual fail to see an object, but if the visual memory of that object can be recalled through the other senses; if, for instance, the individual cannot see a bell, but if the sound given out from it recall the memory of what a bell is like, then the defect is not in the visual area of the occipital lobe, but in the conducting paths leading up to it. We see this condition illustrated in a person who has become blind late in life. It is rendered possible by the intimate relationship subsisting between the centres of special sense; for, granted that a particular sense centre (such as the visual) is not annihilated, the particular memories stored up in it can be aroused through many different paths besides that in most direct communication with the periphery.

It would seem that ordinary sounds are perceived and their memories stored up probably on both sides of the brain. Word-memories, however, so far as clinical experience teaches us, are retained only on the left side. When the word-memory centre, situated as it is somewhere about the posterior two-thirds of the first and second temporal convolutions, is entirely destroyed the individual suffers from a condition which might be called **psychical word-**

deafness—that is to say, spoken language has no meaning, written or printed symbols are also meaningless, and the word-memory cannot be recalled through any other path. The apparatus in which the auditory memory of words has been stored up is destroyed, and hence neither the spoken words themselves nor their equivalent symbols are capable of arousing that memory. (See Case No. VII. referred to by Starr, No. 521, xii. 1890, p. 100.)

This is a different thing from **pure word-deafness.** In pure word-deafness the auditory centre for the memory of words cannot be destroyed, because written or printed symbols may still recall word-memories—that is to say, the individual is not necessarily word-blind. (See Starr's *résumé* of cases, No. 521, xii. 1890, p. 86.) Supposing it to be the case that the word-memory centre is confined to the left side, pure word-deafness can be accounted for on the supposition of a destruction of the auditory paths leading up to that centre rather than on one of destruction of the centre itself. The word-memory centre can still be aroused through paths other than the auditory, and hence it cannot be annihilated. The word-deafness lesion, one would say, *a priori* must resemble the blindness resulting from interference with the optic apparatus leading up to the visual centre rather than that caused by destruction of the visual centre itself.

This explanation may account for the rarity of pure word-deafness. What is usually called *word-deafness* is not this condition pure and simple—that is to say, it is not a condition in which the word-centre can still be stimulated through channels other than the auditory nerve, but rather one in which the word-memory cannot be aroused through any channel whatsoever. It is, in fact, a condition of psychical word-deafness analogous to psychical blindness. The word-centre is defunct, and consequently the word-memory cannot be recalled by any path, however circuitous and indirect it may be.

As the word-centre is obliterated, the individual is also simultaneously word-blind—that is to say, the impress made by the printed or written symbol upon the occipital lobe cannot be translated into its corresponding acoustic image.

Such persons hear well enough. It is not the hearing of the sound, but the interpretation of its significance which is defective. The left side of the brain seems alone to be utilised in divining the meaning of articulate sound, whereas perception of ordinary sound seems to be common to the two sides, and the area concerned with it is probably wider than in the foregoing.

Complete severance of the tract connecting the visual and auditory centres will cut off the path whereby the impression of written and printed symbols is conveyed to the temporal convolutions in order to arouse the corresponding word-memory. Pure word-blindness will arise from this severance, and from no other lesion. Pure word-blindness is not usually accompanied by hemianopsia. Hence the occipital lobe cannot be the seat of it. A lesion a short way in front of the occipital lobe—that is to say, in the line OA, Fig. 453—or anywhere between this and the first temporal convolution, is that which theoretically might be expected to induce pure word-blindness. As a matter of fact this corresponds with the area most often implicated. As previously explained, the tract which is severed is part of the occipito-parietal band, and this underlies the angular gyrus and base of the temporo-sphenoidal lobe generally.

This condition of word-blindness must not be mistaken for one of failure to recognise the object itself. Where, for instance, the printed or written word "bell" fails to arouse any intelligent meaning in the individual, it is quite possible that the object itself would instantly be recognised. The reason of this evidently is that the memory of the ordinary properties of an object derived through vision are stored up in the occipital lobe, and are immediately revived on the object being seen, whereas symbols have their meaning interpreted only on being transferred to the auditory centre in the temporo-sphenoidal lobe. They have no meaning when conveyed elsewhere.

So extensive, moreover, do the connections of the visual centre seem to be that the visual memories, say of a bell, may be aroused in a person who has become blind late in life through many other channels than the optic nerve, as by causing it to be sounded or by allowing the individual to handle it. On the contrary, it should be remembered that if the visual areas are destroyed no amount of communication through other paths will ever revive the visual memories of the body.

Summary.

Pure word-blindness may be regarded therefore as due to a destructive lesion severing the fibres connecting the visual area in the occipital lobe with the auditory area in the temporo-sphenoidal lobe. We have seen that these connections are extensive, and that they pass under the angular gyrus and its neighbourhood. We can quite well understand that on account of the extent of this connection the lesion of word-blindness may not be always exactly confined to one small area, and that the greater the extent of the destruction the more thorough will the resulting functional defect appear to be.

Pure word-deafness, on the other hand, must be due to a severance of communication with the periphery somewhere between the auditory nerve and the word-memory centre in the temporal convolutions.

Psychical word-deafness, or that condition in which the word-memory cannot be aroused through any channel, must be due to a destruction of the word-memory centre itself, or its isolation through separation of the connections it possesses with other parts.

STAMMERING.

936. The speech mechanism consists of a vocal and of an oral element. The vocal element is produced in the larynx, the oral element in different parts of the mouth. Thus in pronouncing the word **satisfy**[1] the laryngeal part of the mechanism comes into play when pronouncing the **a**, **i**, and **y**, while the **s**, **t**, and **f** are in great part, although, in the case of the **t**, not entirely oral. The vocal sound, as in the production of the **a**, is effected by the approximation of the vocal cords. The oral part of the mechanism is of a bifid nature. The oral cavity acts as a resonator whereby the vocal sounds can be modified in tone or timbre as they pass through it; while by different positions of the tongue, lips, and soft palate new sounds can be originated.

Normal speech, as Wyllie remarks, is like playing the violin. It is a wonderfully perfect co-ordination of the vocal and oral parts of speech in eliciting articulate language. The vocal mechanism may be compared to the bow hand of the violinist, the oral part to the string hand. In the pronunciation of the above example the hissing **s** has first to be set off towards the extreme end of the oral cavity, and has to be followed by the purely vocal **a**, and so on throughout the word. There must therefore be some extraordinarily complex motor co-ordinating mechanism whereby the muscular contractions necessary for the vocal and oral acts are correlated and combined.

Neil Arnott (No. 607) appears to have been the first to suggest that stammering was caused by delayed action in the vocal mechanism, and his views have been accepted and amplified in later times by Melville Bell, Merkel, Kussmaul, and Wyllie. The defect appears to be one of true incoordination whereby the vocal part of speech is called forth with difficulty. This supposition is supported by the fact that stammerers have no difficulty in singing or intoning, in which the greater part of the action is purely laryngeal. They are also often relieved in a difficulty by pronouncing a word such as **also**, in which the initial letter is purely vocal—that is to say, the initial **a** has the effect of diverting the individual's attention to the vocal element, and thus relieves the spasm of the oro-linguals or throat muscles as the case may be. It is always the initial syllable of the word which forms the stumbling-block, and whenever the individual's attention is directed away from the oro-lingual or guttural muscles, which, on false principles, the stammerer overstrains, and is fixed upon the laryngeal, the relief is immediate. The difficulty may also be got over by singing the first syllable.

The spasm appears to affect one of two regions. In most stammerers it is the lips which are the seat of it, and the difficulty in such cases is most felt in pronouncing the explosives (**p** and **b**) as the initial letters of a word. In certain cases the spasm is farther back, in the false vocal cords (Wyllie), and is elicited on attempting to pronounce the **k** or hard **ch** as initials.

---

[1] The author begs to acknowledge his indebtedness to Dr. Wyllie's excellent exposition of the subject (No. 19, xxxvii. 1891, p. 289 *et seq.*) for these and other examples, and indeed for most of the following information.

In the treatment of this distressing ailment the evident lesson to be learnt from the study of its pathology is to direct the subject of it to concentrate as much attention as possible upon the vocal part of speech, and thus prevent a fruitless overflow of energy into that part which is more exclusively oral.

General Literature on Aphasia.

Abbots: Impediments of Speech (12th ed.), 1892. **Amidon** (Path. Anat. Sensory Aphasia): N. Y. Med. Journ., xli. 1885, pp. 113, 181. **Archer** (Aphasia in Child, with Remarks on Develop. of Speech-Centre): Dublin Journ. Med. Sc., lxxix. 1885, p. 285. **Bastian:** Brit. and Foreign Med.-Chir. Rev., xliii. 1869, pp. 209, 470; *also*, Lancet, 1890, i. p. 1163; *also*, Brit. Med. Journ., 1887, ii. p. 931. **Bateman:** On Aphasia, 1890. **Berlin** (Dyslexia or Word-Blindness): Arch. f. Psychiat., xviii. 1887, p. 289; *also*, Eine besondere Art d. Wortblindheit, 1887. **Bernard:** De l'aphasie, etc., 1889. **Bouillaud:** Arch. gén. de Méd., viii. 1825, p. 25; *also*, Bull. de l'Acad. de Méd., iv. 1839, pp. 282, 333; *Ibid.*, xiii. 1848, pp. 699, 778. **Broadbent:** Med.-Chir. Rev., xxxvii. 1866, p. 468; *also* (Convolutions of Deaf and Dumb Woman), Journ. Anat. and Physiol., iv. 1870, p. 218; *also* (Amnesia), Trans. Med.-Chir. Soc. Lond., lxi. 1878, p. 147; *also*, Brain, i. 1878-79, p. 484; *also*, Trans. Med.-Chir. Soc. Lond., lxvii. 1884, p. 249. **Broca** (Seat of Faculty of Language): Bull. Soc. d'anthrop. de Paris, iv. 1863, p. 200; *Ibid.*, vi. 1865, p. 377; *also*, Bull. Soc. Anat. de Par., xxxvi. 1861, p. 330; *Ibid.*, xxxix. 1864, p. 293. **Bullen** (Amnesia): Brain, xi. 1888-89, p. 514. **Coën:** Path. u. Therap. d. Sprachanomalien, 1886. **Da Costa** (Amnesic Aphasia and Agraphia): N. Y. Med. Rec., xvi. 1879, p. 555. **Dax (M.)** (Lesions of Left Hemisphere Assoc. with Loss of Memory): Montpel. méd., xxxviii. 1877, p. 233 (read before a med. congress in 1836). **Dax (G.)** (Observations tending to associate Derangements of Speech with a Lesion of Left Hemisphere): Montpel. méd., xxxviii. 1877, p. 230 *et seq.* **Dejerine:** Semaine méd., iv. 1884, p. 449; *also* (Aphasia from Lesions of the Island): Rev. de méd., v. 1885, p. 174. **Dingley** (Amnesia): Brain, viii. 1885-86, p. 492. **Duret** (Researches on Circulation in Brain): Arch. de Physiol., i. 1874, pp. 60, 316, 664, 919. **Freund** (Optic Aphasia): Arch. f. Psychiat., xx. 1888-89, pp. 371, 441. **Gairdner:** On the Function of Articulate Speech, 1866. **Grashey:** Arch. f. Psychiat., xvi. 1885, p. 654. **Heubner** (Topographical Distribution of Vessels of Brain): Die luetische Erkrankung d. Hirnarterien (p. 170), 1874. **Hughlings-Jackson:** Brain, i. 1878-79, p. 304; *Ibid.*, ii. 1879-80, p. 204. **Jacobs** (Functional Aphemia): Brit. Med. Journ., 1890, ii. p. 622. **Kussmaul:** Cyclopædia of Pract. of Med. (v. Ziemssen), xiv. p. 581, Eng. transl., 1878; *also*, Die Störungen der Sprache, 1885. **Lichtheim:** Arch. f. Psychiat., xv. 1884, p. 822; *also*, Brain, vii. 1885, p. 433. **Ogle** (Aphasia and Agraphia): St. George's Hosp. Rep., ii. 1867, p. 117. **Paget:** Brit. Med. Journ., 1887, ii. p. 1258. **Pitres** (Pure Agraphia): Rev. de méd., iv. 1884, p. 855. **Ross:** On Aphasia, 1887. **Sanders:** Edin. Med. Journ., xi. 1866, p. 81; *also*, Lancet, 1866, i. p. 656. **Sérieux** (Case of Sensory Agraphia): Compt. rend. Soc. de biol. iii. 1891, p. 195. **Skwortzoff:** De la cécité et de la surdité des mots dans l'aphasie, 1881. **Starr** (Sensory Aphasia): Brain, xii. 1890, p. 82. **Stewart:** Introduction to Diseases of Nervous System, 1884. **Suckling** (Sens. Aphasia, Word-Blindness, Word-Deafness): Brit. Med. Journ., 1886, i. p. 691. **Thomsen:** Centralbl. f. klin. Med., vi. 1885, p. 417. **Turner** (Word-Deafness): Brit. Med. Journ., 1885, ii. p. 700. **Wernicke:** Die Aphasische Symptomen—Complex, 1874; *also* (Aphasia and Mental Derangement): Deut. med. Wochnschr., xvi. 1890, p. 445. **West** (Aphasia with Lesion in Supra-Marginal and Angular Gyri, Broca's Convol. unaffected): Brit. Med. Journ., 1885, i. p. 1242. **Willbrand:** Die Seelenblindheit als Herderscheinung, etc., 1887.

CHAPTER LXXXII

THE NERVOUS SYSTEM—(*Continued*)

DISEASES OF THE BASAL GANGLIA.

937. THE commonest of these are hæmorrhage, embolic softening, tumours, etc. What the effect of destructive lesion of the individual ganglia in Man may be it is hard to say. The gray masses are so closely knit with the descending cortical fibres that most observations are liable to be vitiated thereby.

In Man the greater part of the **caudate nucleus** appears to be inert. Nothnagel (No. 13, lvii. 1873, p. 184) discovered what he calls a "nodus cursorius" in the caudate nucleus of the rabbit. It lies about its middle and towards the mesial line. When it is punctured and partially destroyed the animal shortly begins to prance like a circus horse. The author has seen this part of the caudate nucleus in Man entirely scooped out by an old softening lesion without a single motor phenomenon.

The **lenticular nucleus** is said to be also motor in its function. But how is it possible to judge of the effects of a focal lesion of a part beset with fibres coming from so many different regions? Its supposed connection with bulbar paralysis is described elsewhere (Sect. 683).

The **thalamus**, when the seat of a focal destructive lesion, is said to be accompanied by *hemichorea* and *unilateral shivering*. Posteriorly it comes into such close relationship with the optic tract that interference with the functions of that nerve is often noticed when it is the seat of tumours, etc.

We probably understand little, if anything, as yet of the function of this ganglion. It is, in the author's opinion, a ganglion essentially bound up with the corpus callosum. It receives a large proportion of the callosal fibres coming from the opposite hemisphere (see Sect. 926).

Literature on Diseases of Basal Ganglia.—**Allan** (Softening of Corp. Striat. and Opt. Thal.): Lancet, 1885, i. p. 797. **Bechterew** (Opt. Thalami): Arch. f. path. Anat., cx. 1887, pp. 102, 322. **Hebold** (Signs of Focal Lesions in Putamen of Lenticular Nucleus): Arch. f. Psychiat., xxiii. 1891, p. 447. **Moore** (Gummata of right Corp. Striat.): N. Y. Med. Journ., xliii. 1886, p. 496. **Shaw** (Softening of Corp. Striat.): Med. News, Phila., xlviii. 1886, p. 106. **Sinkler** (Cyst of Lentic. Nuc.): Journ. Nerv. and Mental Dis., N. Y., xvii. 1890, p. 419.

LESIONS OF THE INNER AND OUTER CAPSULES.

938. Little or nothing is definitely known of the effect of destructive lesions of the **outer capsule.** The present remarks will be directed accordingly to the **inner capsule** alone.

There seems to be a consensus of opinion as to the posterior third of the posterior limb of this capsule being chiefly *sensory*. When it is destroyed *hemianæsthesia* of the opposite side of the body follows. The part from this on to the knee, and probably a short way in front of it, contains the motor fibres descending from the cortex cerebri. And they are so arranged that in all probability the middle third of the posterior segment transmits the fibres connected with movements of the trunk and general actions of the upper and lower extremities. The anterior third possesses fibres bound up with certain movements of the hand and arm, and of the head and neck. The knee and adjoining part of the anterior limb convey those fibres concerned with facial expression and it is said articulation, together with those for special fine movements of the hand, as in writing. The accompanying scheme (Fig. 467), according to Beevor and Horsley, shows the respective seats of the bundles of motor fibres descending from the cortex within the inner capsule.

As a matter of fact it is found that a destructive injury of the inner capsule in the anterior two thirds of the posterior limb calls forth a purely motor crossed hemiplegia; while if the posterior third of the same is also implicated a paralysis of motion and of sensation of the opposite side of the body is the result.

The fibres in the anterior limb are in all likelihood mostly crossed callosal. A slender band seems to pass backwards from the prefrontal region of the same side to become attached to the thalamus (Meynert's anterior peduncle of the thalamus).

A comparatively small lesion in the capsule, it should be remembered, will occasion a much more wide-spread effect than a lesion of corresponding size in the cortex, the reason being that the descending fibres at this point are concentrated. It is followed by descending secondary degeneration, exactly as when the destruction is higher up.

HEMIPLEGIA (ἥμισυς, *half*; and πλῆξις, *a stroke*).

939. **Definition.**—*A condition where one half of the body is deprived of motion or sensation, or of both.* The term "hemianæsthesia" is now usually applied to the paralysis of sensation.

General Vital Phenomena.—It should be remembered that in hemiplegia from a cortical destruction or capsular severance the paralysis of the face is on the same side as that of the body—that is to say, on the side opposite to the lesion. The reason is that apparently the descending cortical fibres connected with the nucleus of the portio dura cross the middle line somewhere about the middle of the pons.

The paralysis affects chiefly the face (its lower aspect) and the upper and lower extremities. The muscles which do not become paralysed are those of the eye, neck, and trunk. Those muscles, in fact, which act bilaterally escape. The explanation generally accepted of this peculiarity was given by Broadbent (No. 148, xxxvii. 1866, p. 477), namely, that, in the case of those muscles which act bilaterally, the nerve nuclei in the cord and medulla are so connected by commissures as to be innervated, practically, from both sides of the brain. They act *pro tanto* as a single nucleus.

Notwithstanding that nearly the whole of a cerebral hemisphere may be destroyed and the pes pedunculi on the same side entirely annihilated by secondary degeneration, Bechterew (No. 517, xix. 1887, p. 15) has shown that the movements of the face engaged in mimicry may remain. This can be explained, he thinks, on either of the following suppositions: (1) from the innervation being bilateral; or (2) from there being motor tracts in the tegmentum.

Rigidity.—When the injury has been caused by a hæmorrhage the muscles of the affected side, in a few days afterwards, may be found in a rigid condition. This is known as **early rigidity,** and is caused by the irritation of the effused mass of blood. It disappears soon, and as the secondary degeneration of the pyramidal tract begins to show itself, is followed by a **late rigidity** or "contracture" of the paralysed muscles. As a rule the attitude assumed by the limbs from the latter cause is *flexion in the upper* and *extension in the lower*. The arm is flexed, pronated, and the hand bent upon the forearm, the whole limb being thrown across the chest. This late contraction in course of time may almost completely pass off.

DISEASE OF THE CRUSTA PEDIS PEDUNCULI.

940. It is within the crusta or superficial under aspect of the cerebral peduncle that the descending fibres are contained. None of them appear to be sensory (see p. 719).

Hæmorrhage takes place occasionally into it, but perhaps the commonest lesion is softening from syphilitic obliteration of the blood-vessels.

The main phenomenon induced by a destructive focal lesion in the neighbourhood is what is known as **alternate paralysis** (Gubler). It will be remembered that the fibres of the third issue at this point. Arising from the nucleus on the floor of the aqueduct, they bend outwards for a certain distance, and interlace with the fibres of the superior cerebellar peduncle as they are passing up to the red nucleus. They subsequently approach the middle line to make their exit between the diverging cerebral peduncles. Some of them cross to the opposite side.

A focus of destruction in this locality is thus liable to implicate the roots of the third as they are making their way outwards, so that there comes to be a paralysis not only of the motor fibres descending to cross in the pyramids, but of the fibres of the third near their point of issue. The consequence is that while the opposite side of the body is more or less hemiplegic, the muscles supplied by the third nerve on the same side of the body are also implicated. There thus results an alternate paralysis.

DISEASE OF THE PONS.

941. **Tumours,** especially *caseous tubercular masses* and *gliomata, hæmorrhage, softenings*, etc., are the usual lesions met with in this situation. The tubercular tumours are sometimes very large, but curiously do not always occasion motor paralysis. The reason for this is that the motor fibres are stretched around them but are not ruptured. Where they involve the roots of the fifth nerve, as pointed out by M'Gregor (No. 59, 1886, ii. p. 1127; *Ibid.*, 1889, i. p. 1079), among other indications of their site, ulceration of the cornea is often present on the same side as that of the tubercular focus. Softenings and other destructive affections which involve the roots of the fifth usually give rise to intense unilateral neuralgic pain extending over the head and face.

The gliomatous tumours spread out diffusely in the substance of the pons, and hence are without a distinctly defined border. They may be unilateral, and when so are productive of much deformity.

Sudden **hæmorrhage** into the pons, if of any size, tends to rupture into the fourth ventricle, and when so brings about a rapidly fatal result. One sign of it is contraction of the pupils and immobility to light reflexes.

When a **focal destructive lesion** is located in the pons the paralytic phenomena which ensue depend greatly upon the site. The motor fibres of the cerebral cortex connected with the nucleus of the portio dura appear to cross about its middle (see *Hemiplegia*) in their descent. If the area of destruction is situated laterally in the **upper half** of the pons, the descending fibres for the extremities and those for the portio dura will be nipped across consequently before they have decussated, and a complete *crossed hemiplegia* will follow. In the lower half of the pons, however, the cortical fibres to the portio dura have already crossed, while those for the extremities have not. If the focal lesion be situate here it will give rise accordingly to an *alternate paralysis* of the muscles innervated by the portio dura and those of the extremities. The face will be paralysed on the same side as the lesion, the extremities on the opposite.

As afterwards detailed (Sect. 955), destructive lesions of the lower half of the pons are liable to be followed by *conjugate deviation of the eyeballs*, owing to paralysis of the co-ordinating centre in the vicinity of the abducens nucleus. The deviation is towards the *sound* side. When, however, the centre is merely stimulated, the deviation may be towards the *injured* side.

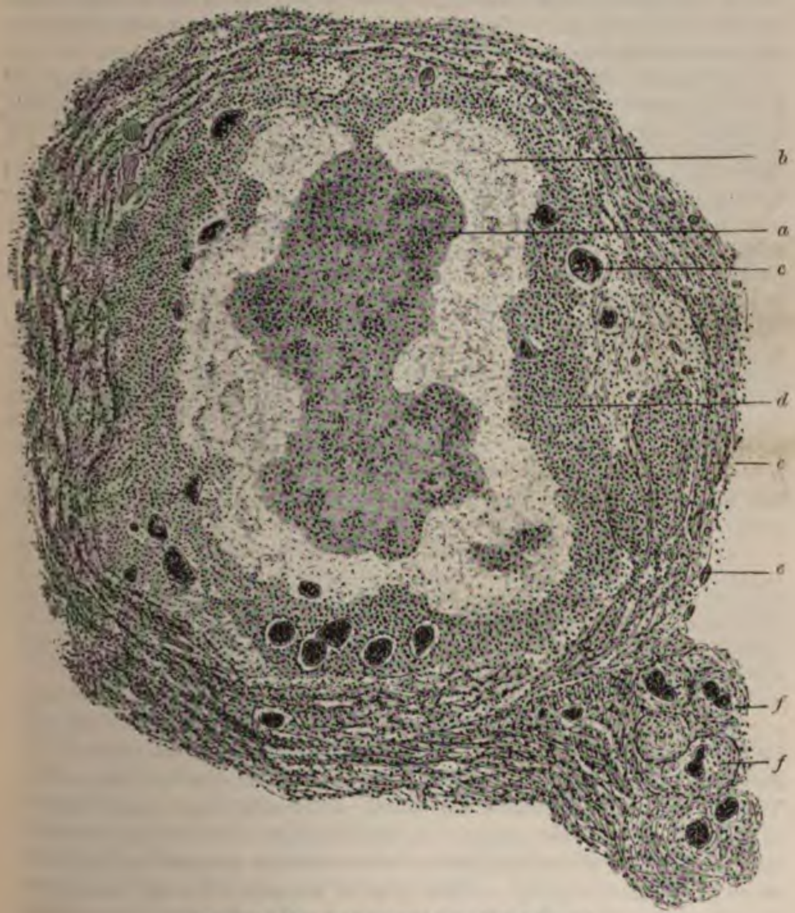


FIG. 456.—TUBERCLE OF THE PONS (×300 DIAMS.)

(*a*) Central, very caseous part; (*b*) part around this less caseous and granular; (*c*) giant cell in cellular part (*d*) as yet free from caseation; (*e*, *e*) capsule-like condensed tissue at margin; (*f*, *f*) secondary tubercles formed from the primary large growths (Hæmatoxylene and Eosin, Clarified).

Disease of the Semicircular Canals, Cerebellum, and Olivary Bodies—Disturbance of the Function of Equilibration.

942. **Anatomical Connections.**—Both Deiters and Meynert have made out a close anatomical connection between the *cerebellum* and *olivary bodies*. The connection, as Meynert remarks, is probably crossed. Unilateral atrophy of the cerebellum has been found accompanied by atrophy of the opposite olive.

The superior cerebellar peduncle, it will be remembered, after issuing from the cerebellum passes under the posterior couple of corpora quadrigemina in a mass of fibres which on cross section has a half-moon shape. Opposite the point of issue of the trochlearis, fibres begin to leave it, which run towards the middle line and pass over to the opposite side. This forms the commencement of a decussation continued upwards to a point corresponding to the posterior aspect of the anterior couple of corpora quadrigemina. According to Stilling, Meynert, Forel, and others, the decussation is complete, but others, such as Arnold and Mendel, maintain that it is only partial. However this may be, the fibres again collect themselves into a compact bundle in the neighbourhood of the red nucleus.

The theory that is most prevalent, although it is not universal, regarding the relationship of these fibres to the ganglion cells of the red nucleus is that they become united to them. Forel supposes that they simply surround the ganglion without forming an attachment to its cells ; that fresh fibres arise from it ; and that these combine with the ascending peduncle in its progress upwards. Thence it is difficult to follow their course. Meynert was of opinion that they entered the inner capsule and formed part of the corona radiata. Forel, on the contrary, traces them into the thalamus, where they terminate by constructing the laminæ medullares lying to the outer border of that body.

The points of origin of the fibres within the cerebellum are, to say the least of it, as yet doubtful. Stilling, for instance, limits them to certain definite localities of the cerebellar gray matter ; while Vejas, from experimental evidence, comes to the conclusion that they are drawn from the entire cortical gray matter. Bechterew, studying the matter from the developmental point of view, makes out the composition of the peduncle and its points of origin to be a more complex matter.

Nature of Lesions.—Besides *cheesy and other tumours*, the cerebellum is sometimes the seat of a *focal hæmorrhage* or an *abscess*. The abscess usually follows in the wake of septic ear disease (see p. 573). The cheesy tumours, which are usually tubercular, may reach the size of a walnut or small orange. A hæmorrhage into the middle lobe of the cerebellum proves fatal almost always within a matter of six hours, often much more rapidly. This is to be accounted for by the sudden pressure exerted by the effused blood upon the vital parts on the floor of the fourth ventricle.

Functional Effect of Lesions.—It has long been known that disease of the internal ear is often accompanied by vertigo. The connection between the two, however, was emphasised by Ménière (No. 204, 1861, p. 29 *et seq.* ; see, also, Synopsis of Literature by Knapp, No. 553, ii. No. 1, 1871, p. 229), so that the term **Ménière's disease** has come to mean a form of giddiness accompanied, among other things, by partial deafness.

Through the researches of Crum-Brown (No. 5, viii. 1874, p. 327) and others it has been ascertained that the **semicircular canals** act as peripheral sense organs affected by rotation. Impressions made upon them indicative of the position of the body are conveyed through the acoustic nerves to the brain. One of their great functions, accordingly, is that of balancing the body by calling into requisition the muscles necessary for the maintenance of the erect posture. When the semicircular canals are diseased or when the acoustic nerves are divided (Bechterew, No. 169, xxx. p. 312), the power of balancing the body, as might be expected, is much interfered with, so much so that an animal with divided acoustics cannot walk. The liquid in the canals, by its inertia, stimulates their epithelial lining when movements are made in certain directions. The particular canal stimulated affords an indication of the position of the body. The vertigo which follows disease of the semicircular canals or division of the acoustic nerves is due to failure to perceive this stimulus.

The semicircular canals, however, do not appear to be the only peripheral structures which are endowed with this function. From the experiments of Christiani (No. 554), and more particularly those of Bechterew (No. 169, xxxi. 1883, p. 479), it appears that the **gray matter of the third ventricle** also plays the part of a balancing organ. When different parts of the wall of the third ventricle are injured, the same difficulty in progressing, from loss of the faculty of balancing the body, is experienced. Indeed, it is just a question whether the **walls of the entire ventricular system** are not endowed with the power of indicating position.

At the autopsy of a man who suffered from Ménière's disease the author found two tumours loosely attached to the choroid plexus and floating freely in the distended lateral ventricles. There was no distinct evidence of disease of the ear. It is possible that the two tumours dangling loosely in the ventricular liquid may have stimulated the epithelium and excited symptoms of vertigo.

Vertigo may, however, also follow from disease of the centres which receive the peripheral stimuli. The olivary bodies and cerebellum seem to be the two centres endowed with this property. Bechterew (No. 169, xxix. 1882, p. 257) has shown that when the **olivary bodies** are excised experimentally, the animal is unable to walk from the disturbance induced in its balancing functions. If destroyed on one side only, a rocking motion follows, with an inclination towards the side of injury. He believes that the olives are organs to which centripetal tactile impulses are conveyed on their way to what he regards as the great central organ of equilibration, namely, the cerebellum.

Similar effects, it is known, result from destruction of the **cerebellum** itself or of its peduncles. Indeed one of the chief functions of this organ appears to be that of receiving peripheral impressions necessary for keeping the body in the erect position. It appears to be a centre in which impressions received from the inner ear, the epithelium lining the ventricles, and the soles of the feet are correlated and adjusted for balancing purposes.

Disease located within it is almost always followed by loss of equilibrium. Thus the presence of a tumour in its substance usually gives rise to a reeling or staggering gait, with a tendency to fall to one side. When the tumour is situated in the upper part of the middle lobe the tendency is to fall backwards. When in the lower part of the same the inclination is to fall forwards or to revolve round a horizontal axis. When in a lateral lobe the person falls towards the side in which the tumour resides (Ross). Tonic contraction of the muscles of the neck and rotatory movements of the eyeballs are sometimes noticed. These may, however, be caused accidentally by pressure on adjacent parts.

Large caseous tumours may nevertheless develop within a lobe of the cerebellum without almost a symptom to indicate their locality, provided their growth is slow.

Literature on Diseases of Cerebellum (see also *Tumours of Brain*).—**Becker** (Lesion of Cerebellum): Arch. f. path. Anat., cxiv. 1888, p. 173. **Bristowe** (Tubercle): St. Thomas' Hosp. Rep., 1884, xiv. 1886, p. 81. **Broadbent** (Hæmorrhage in Young Girl): Trans. Path. Soc. Lond., xv. 1864, p. 4. **Curschmann** (Clinical and Experimental on Pedunculus Cerebelli): Deut. Arch. f. klin. Med., xii. 1874, p. 356. **Ebstein** (Osteoma): Arch. f. path. Anat., xlix. 1870, p. 145. **Hebra** (Tubercle in Right Hemisphere): Vierteljahrschr. f. Dermatol. u. Syph., iii. 1876, p. 508. **Mosler** (Softening in Left Hemisphere): Deut. Arch. f. klin. Med., xv. 1875, p. 229. **Nothnagel**: Berl. klin. Wochnschr., xv. 1878, p. 205. **Ogilvie** (Destruction of Right Hemisphere): Brain, viii. 1885-86, p. 405.

DISEASES OF THE MEDULLA OBLONGATA.

943. Hæmorrhage into the medulla is not so common as into the pons. Possibly this is because the former contains much more fibrous tissue than the latter, which acts as a support to the vessels.

An unusual **hardness** of the medulla, almost amounting to that of cartilage, is met with. It has been referred to by Schroeder v. d. Kolk, and is common in chronic epileptics. It is due to an increase of the connective tissue naturally present in the medulla. In the neighbourhood of the olives it is prolific.

The **laryngeal motor and sensory disturbances** traceable to the medulla oblongata are, according to Eisenlohr (No. 517, xix. 1887, p. 314)—

(1) Those resulting from bulbar paralysis.

(2) Those accompanying multiple sclerosis.

(3) Those associated with locomotor ataxia.

(4) Those following upon circumscribed diseases, such as local inflammations, embolism, and thrombotic softening.

The **tabetic affections** are primary spastic conditions (laryngeal crises), disturbances of sensation such as anæsthesia of the mucous membranes, with anomalous reflexes, partial paralysis or paresis, and, lastly, atactic affections of the laryngeal musculature.

Glosso-labial Paralysis.

944. *Syn.*—"Progressive paralysis of the tongue, velum palati, and lips" (Duchenne); "Labio-glosso-laryngeal paralysis" (Trousseau);

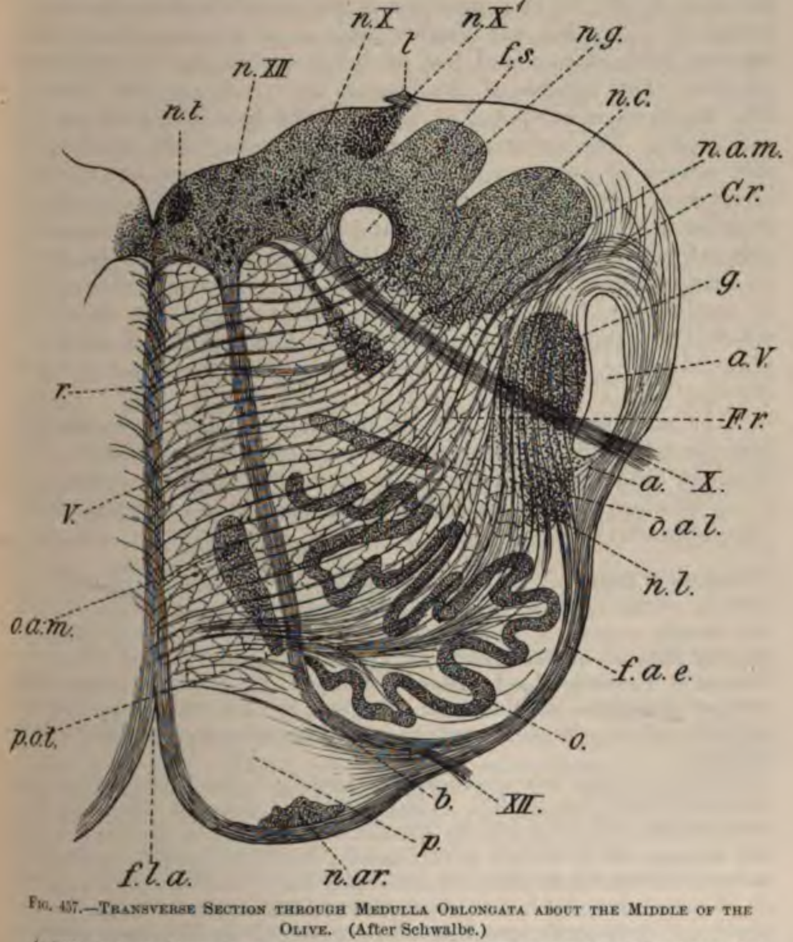


FIG. 457.—TRANSVERSE SECTION THROUGH MEDULLA OBLONGATA ABOUT THE MIDDLE OF THE OLIVE. (After Schwalbe.)

(*n.* XII.) Nucleus of hypoglossus; (*n.* X.) part of nucleus of vagus rich and (*n.* X'.) part of nucleus of vagus poor in cells; (*n.t.*) nucleus of funiculus teres; (XII.) hypoglossal nerve; (X.) vagus nerve; (*n.am.*) nucleus ambiguus; (*n.l.*) nucleus of lateral tract; (*o*) olivary nucleus; (*o.a.l.*) outer accessory olive (Nebenolive); (*o.a.m.*) inner accessory olive; (*n.g.*) nucleus of funiculus gracilis; (*n.c.*) nucleus of funiculus cuneatus; (*g*) substantia gelatinosa; (*a.* V.) ascending root of the 5th; (*f.s.*) funiculus solitarius (respiratory bundle); (*t*) point of departure of the tænia sinus rhomboidalis; (*C.r.*) corpus restiforme; (*p*) anterior pyramid girdled by the fibræ arciformes externæ (*f.a.e.*), which in part sink deeply at *b*, and which partly run superficially into the restiform body at *a*, and partly sink more deeply into the substantia gelatinosa at *g*; (*p.o.l.*) pedunculus olivæ joining the raphé (*r*); (*F.r.*) formatio reticularis; (*f.l.a.*) fissura longitudinalis anterior; (*n.ar.*) nucleus arciformis.

"Progressive bulbar paralysis" (Wachsmuth); "Amyotrophic bulbar paralysis" (Leyden).

Vital Phenomena.—These consist essentially in a paresis, followed, it may be, by a paralysis of the muscles connected with the *tongue*, *soft palate*, *lips*, and possibly, later on, of the *pharynx* and *larynx*, together with wasting and loss of reflex excitability of the muscles affected. The muscles of the tongue, as a rule, are first involved. The functions most disturbed are those of speech, deglutition, and respiration. The motor oculi muscles may, practically speaking, be said always to escape, and sensory complications are of the rarest occurrence. The advent of the disease is usually insidious, and the progress of the malady towards a fatal issue certain. Death is seldom delayed beyond three years from the commencement of the attack. In a large proportion of instances general progressive muscular atrophy of hands, arms, loins, and lower extremities ensues. In those from which it is absent death occurs early from some cardiac or other complication. The branches of the facial involved are those going to the lips.[1]

The paralysis of the muscles is essentially atonic; the muscle fibre becomes soft, limpid, and spongy, and contractures are absent. The muscular atrophy is most evident in the tongue and lip muscles.

Sensibility, intelligence, and the functions of the sphincters usually remain intact.

Nature of Disease.—Duchenne (see Bibliog.) was the first to describe its clinical features. When the lesion causing the disease was discovered, its resemblance to that causing progressive muscular atrophy became subject of note. Duchenne regarded them as separate diseases, although he confessed that they sometimes occurred in the same subject. He never admitted that there was atrophy of the labio-palato-glossal muscles in bulbar paralysis. He said, "Bulbar paralysis is a paralysis without atrophy; progressive muscular atrophy an atrophy without paralysis."

These views have been considerably modified by further experience, and even Duchenne himself, latterly, in a manner admitted a connection between the two. Opinion at the present day is pretty well that of Charcot and his followers (see Pitres and Sabourin, No. 4, vi. 1879, p. 729), namely, that *bulbar paralysis is the result of lesions of the medulla oblongata identical in their nature with those of the spinal cord which underlie progressive muscular atrophy.* And also that the disease is of two kinds—(1) a **protopathic form**, in which the motor cells are the primary seat of the degeneration; and (2) a **deuteropathic form,** in which the affection of the motor cells is consecutive to a primary fasciculated sclerosis of the lateral columns, along with destruction of the nerve cells in the anterior horn.[2] The muscular atrophy in bulbar paralysis is secondary to the degeneration of the nerve centres.

---

[1] There is a difference of opinion as to the innervation of the soft palate. Some say it owes its nerve supply to the portio dura. It is more likely traceable, according to W. A. Turner (No. 5, xxiii. 1889, p. 523), to the internal branch of the spinal accessory (nervus accessorius vagi), whose fibres are distributed along with certain branches of the vagus.

[2] See Amyotrophic Lateral Sclerosis.

The Lesion.—The minute changes are as follows:—The *hypoglossal nucleus* is the one upon which the degeneration chiefly takes hold. What Duval (No. 200, September 1876) has described as the "accessory hypoglossal nucleus," that arm of gray matter which shoots forwards and outwards from the hypoglossal nucleus proper, is usually also overtaken, but to a less extent. The degeneration of the nerve cells is ushered in by a deposition of pigment around the nucleus, a destruction of the processes of the nerve cells next takes place, and this is followed by a shrinking of the protoplasm and ultimate destruction and disappearance of the entire nerve cell. In evident examples of the disease the multipolar cells of the classical hypoglossal nucleus may have entirely vanished, while a few remain in the accessory nucleus partially invaded by the degeneration.

The motor cells of the nuclei of the *pneumogastric*, *glosso-pharyngeal*, and *spinal accessory* are more or less affected in a similar manner. The motor cells of the *facial* have sometimes advanced in the degeneration.

As before remarked, the *spinal cord* is often involved, and here, as in the medulla oblongata, it is the *motor cells* which have mostly suffered. The posterior cornua, columns, and nerve roots are, as a rule, remarkably healthy. Throughout the highest levels of the cord the number of cells implicated may be small, but as the cervical enlargement is reached the destruction may possibly be so vast that there are areas of the cord in which hardly a multipolar nerve cell remains in the anterior horns. In the dorsal region the degeneration becomes less evident, but in the lumbar enlargement, again, a few diseased cells may be seen in each motor group. Clarke's columns remain unimpaired (Leyden).

Along with the degeneration of the nerve cells in the cord there is often degeneration of the *pyramidal tracts*. The degeneration, according to Leyden (No. 517, viii. 1878, p. 654), closely resembles that of descending secondary degeneration of Türck and is most pronounced in the *crossed tract*. The remainder of the antero-lateral column may also be involved, but to a much less degree. The degeneration proceeds upwards as far as the middle of the pons, but thereafter is lost. It is most evident in the cervical enlargement and in the higher dorsal levels, but may extend downwards to the lumbar region.

The spinal nerve fibres involved in the degenerated tract are atrophic (Leyden), their transverse measurement is diminished, the medulla is reduced in bulk or absent, and the axis-cylinders are thin and never swollen as in true sclerosis. The connective tissue is converted into a fine-meshed network, which in cases of minor intensity contains oil globules. In more severe cases, compound granular corpuscles are found lying in the degenerated parts.

The fibres of the *hypoglossal nerve* are generally the seat of extreme fatty degeneration. The myeline becomes segmented and absorbed in places. There are only a few fibres in which a cylinder-axis can be clearly made out, and oil globules are abundant. Other nerve trunks connected with the paralysed muscles are implicated in varying degrees.

The **muscular fibres** of the tongue present a shrunken appearance and in many places have vanished. The spaces left between them are either filled with fat or simply with increased connective fibrous tissue. Other muscles, however, in addition to being reduced in size, show large numbers of oil globules in their interior—a true fatty degeneration. Pigment granules are seen in and around them.

The Lenticular Nucleus and Bulbar Paralysis.—Many cases are now on record where the disease has been due to cerebral causes (see Ross, No. 521, v. 1883, p. 145; Raymond and Artaud, No. 528, vii. 1884, p. 145; and others). Ross draws attention to several cases where the lesion, a focal apoplexy, a cystic cavity, etc., was located in the lenticular nucleus or in both lenticular nuclei. He supposes that the path between the cortex cerebri and medulla oblongata is cut across, and that the symptoms are due to this, not to the damage inflicted on the lenticular nucleus itself. There is this difference in the character of the disease when of cerebral origin, namely, that it comes on suddenly and is sometimes at first associated with aphasia and with some paralysis of the extremities. These epiphenomena, however, soon pass off.

On turning to p. 632 it will be found that the outer capsule is described as partly composed of fibres which descend from the third frontal convolution and operculum. Quite possibly it is by pressing upon these or by tearing them asunder that the lenticular nucleus origin of the disease is to be accounted for.

Literature on Bulbar Paralysis.—**Adamkiewicz:** Charité-Ann., v. 1880, p. 353. **Bäumler:** Arch. f. Psychiat., viii. 1877-78, p. 210. **Beevor and Horsley:** Brain, v. 1882-83, p. 403. **Dejerine:** Arch. de physiol. norm. et path., ii. 1883, p. 180. **Duchenne:** Arch. gén. de méd., 1860, ii. pp. 283, 431; *also* Reprint; *Ibid.*, i. 1870, 539; *see also* Collected Works, N. Syd. Soc., 1883, p. 143. **Duchenne and Joffroy:** Arch. de physiol. norm. et path., iii. 1870, p. 499. **Duval and Raymond:** Archives de physiol. norm. et path., vi. 1879, p. 735. **Freund:** Deut. Arch. f. klin. Med., xxxvii. 1885, p. 405. **Leyden:** Arch. f. Psychiat., viii. 1878, p. 641. **Lichtheim** (Apoplectiform): Deut. Arch. f. klin. Med., xviii. 1876, p. 593. **Maier:** Arch. f. path. Anat., lxi. 1874, p. 1. **Mann** (Apoplectic): Brain, vii. 1884-85, p. 244. **Oppenheim and Siemerling:** Berl. klin. Wochnschr., xxiii. 1886, p. 791. **Pitres and Sabourin:** Arch. de physiol. norm. et path., vi. 1879, p. 723. **Raymond and Artaud** (Cerebral Origin): Arch. d. Neurologie, vii. 1884, p. 145. **Ross** (Cerebral Origin): Brain, v. 1882, p. 145. **Senator** (With Sensory Affection): Arch. f. Psychiat., xi. 1880, p. 713. **Shaw** (B. P. without Lesion of Medulla): Brain, xiii. 1890, p. 96. **Tooth and Turner** (Bulbar Paralysis): Brain, xiv. 1891-92, p. 473. **Willigk** (Apoplectiform): Deut. Arch. f. klin. Med., xxii. 1878, p. 101.

CHAPTER LXXXIII

THE NERVOUS SYSTEM—(*Continued*)

DISEASES OF THE OPTIC-CONDUCTING APPARATUS, AND OF THE CENTRES CONNECTED WITH IT.

THE OPTIC CONNECTIONS.

945. THERE is perhaps no nerve in the body whose origin is so subtle and diffused as the optic. Seeing that through the optics a greater number of impressions are conveyed to the brain than through any other channel, this might only be expected. It can be said without exaggeration that there is hardly a faculty of the brain which is not in some way bound up with the sense of sight.

The Chiasma.—In Man and in nearly all the higher mammals the decussation in the chiasma is incomplete. The direct fibres lie at its outer and upper border. Stilling (No. 14, xviii. 1880, p. 472) is of opinion that the uncrossed fibres are just about as numerous as the crossed. This is not the general opinion at the present day. It is usually held that the uncrossed bundle is somewhat smaller than the crossed. The uncrossed fibres supply the outer aspect of the retina, while the crossed are distributed to the inner and posterior regions.

Ganglionic and Cortical Origins.—The origins of the optics may be divided into two sets—the ganglionic and cortical. By the ganglionic sources of origin are meant those which are rudimentary, and which are found to be common to the whole of the vertebrate kingdom; and by the cortical, those which apparently are superadded as the cortex of the cerebrum becomes more and more evolved.

Ganglionic Connections of Optic.

946. Before v. Gudden's researches on the terminations of the optic nerve were published (No. 518, xx. 1874, p. 249) it was customary to regard the optic tract as being connected not only with

the anterior corpora quadrigemina, pulvinar, and external geniculate bodies, but also with the internal geniculate bodies and the posterior corpora quadrigemina. By the peculiar method of investigation which bears his name, v. Gudden, however, made out that the primary optic centres are to be looked upon solely as the anterior corpora quadrigemina, the corpora geniculata externa, and the adjacent parts of the thalamus opticus. He afterwards persuaded himself that the corpora geniculata interna and the posterior corpora quadrigemina have no connection whatever with the optics (No. 517, ii. 1870, p. 711). Forel practically agrees with v. Gudden in these particulars (No. 517, vii. 1877, p. 393).

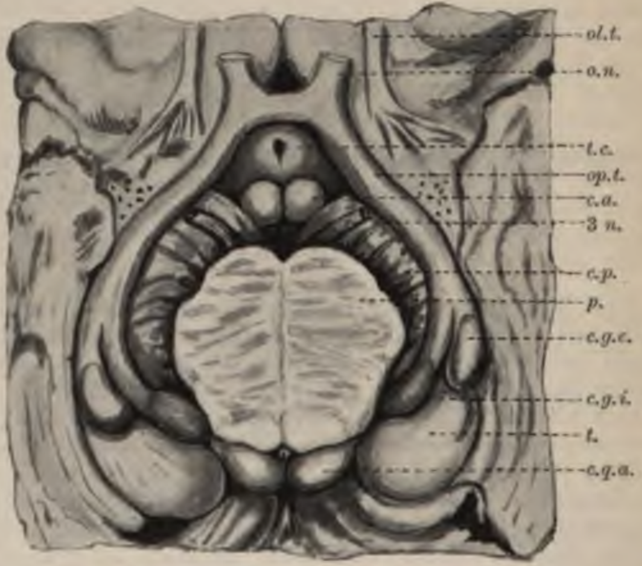


FIG. 458.—DISSECTION OF THE COURSE OF OPTIC TRACT.

(*ol.t.*) Olfactory tract; (*o.n.*) optic nerve; (*t.c.*) tuber cinereum; (*op.t.*) optic tract; (*c.a.*) corpus albicans; (3 *n.*) third nerve; (*c.p.*) cerebral peduncle; (*p*) pons; (*c.g.e.*) corpus geniculatum externum; (*c.g.i.*) corpus geniculatum internum; (*t*) thalamus; (*c.q.a.*) corpus quadrigeminum anterius.

Darkschewitsch's histological researches (No. 51, 1886, Anat. Ab., p. 266) also support the view just quoted as that of v. Gudden. His conclusions are briefly as follows :—

(1) The posterior corpus quadrigeminum is not connected with the tractus opticus.

(2) The corpus geniculatum internum, similarly, has no connection with optic fibres.

(3) He throws doubt upon the pulvinar being a primary optic centre, and says that the most of the fibres going to this body may be traced uninterruptedly through it to the anterior corpus quadrigeminum.

(4) He is sceptical even of the alleged origin from the external 'geniculate body, the fibres which apparently enter it, he says, passing in reality through it. He explains the diminution in size of this body which follows enucleation of the opposite eyeball by shrinkage of those fibres.

(5) Darkschewitsch accepts, in fact, only one primary centre for the visual fibres of the optic, namely, the anterior corpus quadrigeminum, although he admits that other fibres derived from the pineal gland and ganglion habenulæ join the optic in the neighbourhood of the external geniculate body, but these he regards as pupillary in their distribution and function.

(6) He cannot support the view of Charcot (No. 524) that optic fibres cross in the corpora quadrigemina and become implanted in the substance of the corpora quadrigemina of the opposite side.

(7) He cannot find any evidence of either the pulvinar or corpus geniculatum externum being connected to the cortex by a special bundle of fibres, and thinks that the diminution of their size in v. Monakow's experimental extirpation of portions of the cortex must have been due to shrinkage of the fibres which surround them. He grants, however, that there may be a bundle connecting the anterior corpora quadrigemina with the gray mantle of the hemisphere.

It would thus seem that recent researches tend to fix the main ganglionic point of origin of the human optic tract in the **anterior corpus quadrigeminum,** any further attachments which the tract possesses in this neighbourhood being small and somewhat ill defined. At the most the corpus quadrigeminum anterius, the corpus geniculatum externum, and the pulvinar seem to be the extent of the rudimentary or ganglionic connections.

Comparative Anatomy.—This is very much what might be expected. *In the fish*, the optic lobes, which are considered to be the homologues of the anterior corpora quadrigemina, apparently constitute the sole points of origin of the nerve. *In the bird*, where the thalamus is large relatively to the size of the rest of the brain, a branch is superadded from this ganglion, a branch which possibly is represented in Man by that which issues from the pulvinar.

In the higher Mammalia, however, and, as might be supposed, *in Man*, these branches of the nerve become comparatively insignificant. It is even doubtful whether the centres from which they spring have anything to do with vision. As the cerebral mantle increases in extent and complexity, the functions of vision proper which originally were resident in the above ganglia apparently become transferred to it.

Cortical Connections of the Optic.

947. A complete account of these would be far beyond the possibilities of the present treatise. Gratiolet was of opinion that the optic nerve communicated with almost every region of the cerebrum, and although this may be an overstatement of the extent of its ramifications, yet it must be said that the cortical connections of this nerve are far more widespread than is generally supposed.

They commence at the posterior aspect of the chiasma and are continued backwards nearly as far as the geniculate bodies. On looking at Fig. 458 it will be seen that the optic tract in its course backwards is in contact with the anterior perforated space, and has the pedunculus cerebri lying to its inner side and somewhat above it. If an attempt be made to dissect the tract off from these parts in the fresh brain it will be found that so firmly is it attached to them that it is necessary absolutely to cut through the bond of communication before the tract can be disunited. As may be seen on superficial examination, the bond of union is not connective tissue, but white brain substance. This white brain substance includes many of the most important cortical connections of the nerve.

In the various drawings given of perpendicular sections of the brain in Figs. 436 to 443, it will be noticed that the parts which immediately overlie the optic tract are the basal ganglia.

One of the chief connections of the optic with the cortex appears to be effected through the **lenticular nucleus loop** and the **striæ medullares** intersecting the lenticular nucleus. The lenticular nucleus loop is derived mainly from the coalition of these striæ medullares below the lenticular nucleus. When it is examined with a low power after staining by the hæmatoxylene-copper method it is seen to be composed of a dense network of nerve fibres. A great part of the fibres issuing from this network enter the optic tract. Immediately over the chiasma there is a specially large bundle of these which goes by the name of Meynert's commissure. The remainder of the fibres of the lenticular nucleus loop passes into the inner capsule, and, it is generally supposed, run downwards in the pedunculus cerebri.

The striæ medullares appear to be in great part simply a contingent of the fibres descending from the vertex, but they also receive contributions from those fibres passing through the lenticular nucleus from without inwards (Fig. 441, L. N.). Hence possibly the optic may be connected directly with this ganglion through these latter fibres.

Then some of the cortical connections of the optic evidently reach that nerve through the **outer capsule** (Fig. 459, *o.c.op.*). The point where they are most abundant is towards the posterior extremity of the lenticular nucleus.

Others are derived from the **temporo-sphenoidal lobe** (Fig. 459, *t.s.l.f.*, *t.s.l.f.*), and mainly from the vicinity of the first and second temporal convolutions.

The connections with the **occipital lobe** are more difficult to follow, but evidently the fibres run forwards in the occipito-parietal band (Fig. 445) and join the tract towards its posterior limit.

Conclusions.—Without entering into too minute detail it may be said, therefore, that, through the striæ medullares and their union below in the lenticular nucleus loop, as well as through the outer capsule, the optic is in communication with that part of the cerebral cortex in which the motor centres are located; that it is also in direct communication with the first and second temporal convolutions; and that the fibres which reach it from the occipital cortex pass along the occipito-parietal band.

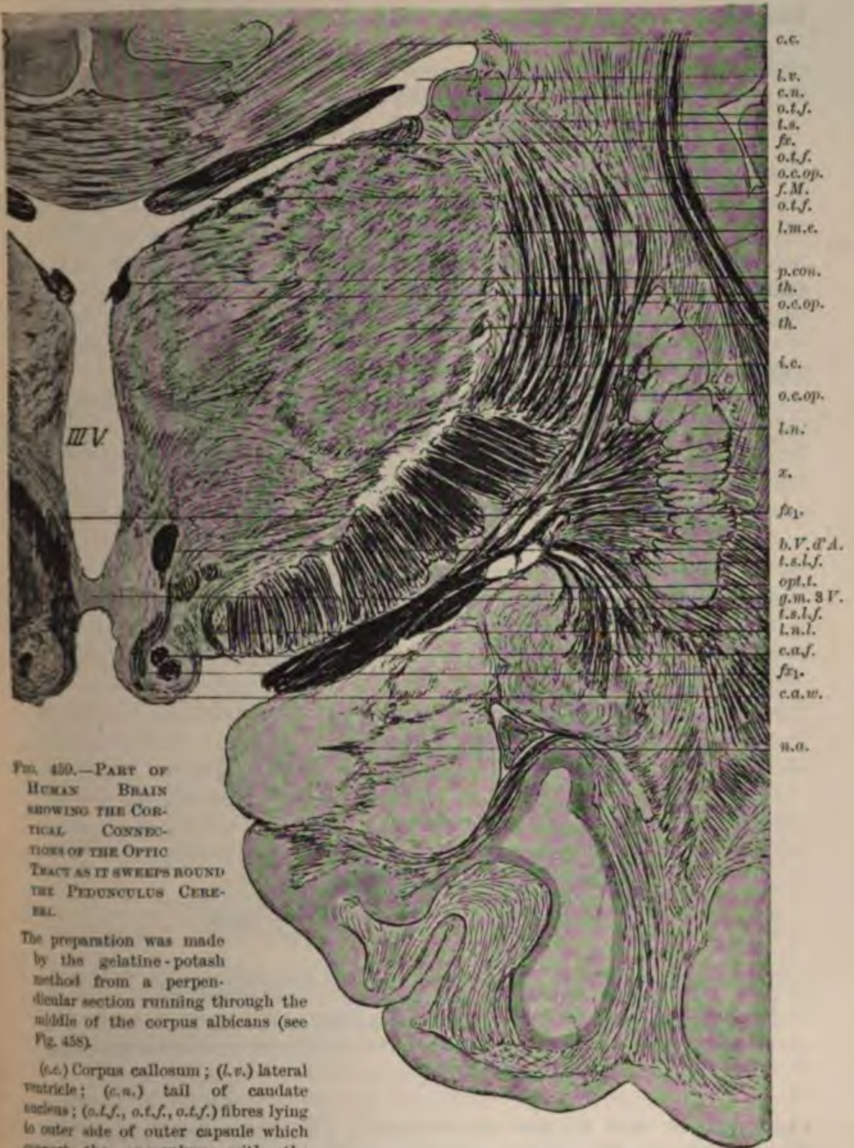


FIG. 459.—PART OF HUMAN BRAIN SHOWING THE CORTICAL CONNECTIONS OF THE OPTIC TRACT AS IT SWEEPS ROUND THE PEDUNCULUS CEREBRI.

The preparation was made by the gelatine-potash method from a perpendicular section running through the middle of the corpus albicans (see Fig. 458).

(*c.c.*) Corpus callosum; (*l.v.*) lateral ventricle; (*c.n.*) tail of caudate nucleus; (*o.t.f.*, *o.t.f.*, *o.t.f.*) fibres lying to outer side of outer capsule which connect the operculum with the temporo-sphenoidal lobe; (*t.s.*) tænia semicircularis; (*fx*) arch of the fornix; (*o.c.op.*, *o.c.op.*, *o.c.op.*) fibres of outer capsule running down into the optic tract (*opt.t.*); (*f.M.*) foramen of Monro; (*l.m.e.*) lamina medullaris externa; (*p.con.*) pedunculus conarii; (*th*, *th*) thalamus; (*i.c.*) inner capsule fibres descending into the pedunculus cerebri; (*l.n.*) lenticular nucleus; (*x*) fan-shaped expansion of fibres mainly derived from the outer capsule entering the optic tract; (fx_1, fx_1) fibres of the fornix passing upwards after having turned round in the white substance of the corpus albicans (*c.a.w.*); (*c.a.f.*) part of the same fornix fibres before they have circumvented the corpus albicans; (*b.V.d'A.*) band of Vicq d'Azyr composed of part of the same fornix fibres running up into the thalamus; (*t.s.l.f.*, *t.s.l.f.*) fibres issuing from the temporo-sphenoidal lobe and joining the optic tract (*opt.t.*); (*g.m. 3 V.*) gray matter on floor of the third ventricle (*III.V.*); (*l.n.l.*) part of lenticular nucleus loop turning round the lower extremity of the peduncular fibres; (*n.a.*) nucleus amygdalaris.

Effect of Removal or Destruction of the Eyeball.

948. The greater bulk of the optic fibres seem to *degenerate in a direction upwards.* So that where the eyeball has been enucleated or completely destroyed for a number of years, and particularly if in early life, the corresponding **nerve** suffers almost complete destruction. Little more than the sheath and the fibrous septa is left. The opposite nerve remains intact and of normal dimensions. The degeneration, if seen sufficiently early, is accompanied by the presence of compound granular corpuscles, as in an ordinary secondary degeneration of any other nerve tract.

It would thus almost appear that the **trophic centres** for the optic nerve fibres connected with vision proper are mainly located in the **retina.** Certain of those fibres of the optic concerned with visual reflexes probably have their trophic centres elsewhere.

An indentation is sometimes noticed on the same side of the **chiasma** as that of the enucleation. The chiasma appears consequently less bulky on this side than on the other. The indentation is caused by the destruction of the direct band of fibres.

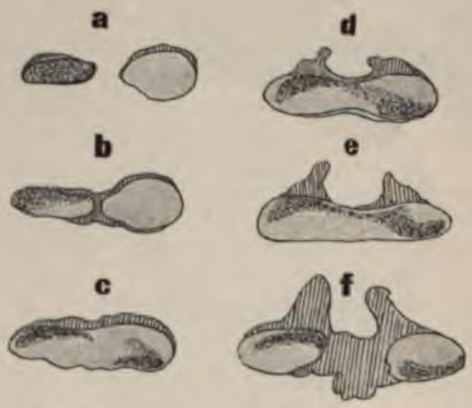


Fig. 460.—The Optic Nerves, Chiasma, and Tracts in a Case of Unilateral Glaucoma. The Stippled Shading corresponds to the Tract of Degeneration.

(*a*) The nerves; (*b*) the same just in front of the chiasma; (*c*) the chiasma anteriorly; (*d*) the chiasma about its middle; (*e*) the chiasma posteriorly; (*f*) the two tracts and adjoining gray matter.

While the difference in size of the two nerves is so notable a feature there is little alteration to be seen in the relative size of the **tracts.** The opposite tract is usually a little smaller than that on the side of the injury, but in the oldest-standing cases, even where the defect may have lasted for a matter of sixty or seventy years, it is hard to detect much difference between them.

The tracts, however, are both smaller than in health and present a flattened appearance. On microscopic examination a path of degeneration is found in each. That in the tract of the same side as the ocular defect lies on the dorso-mesial aspect and dips into the centre of the tract; while that in the crossed tract occupies the ventral aspect and lies peripherally (Fig. 460, *f*).

It is said that **in animals** the **nerve nuclei** which suffer are the anterior corpus quadrigeminum, the corpus geniculatum externum, and the pulvinar, all on the opposite side. These, it is asserted, become flattened and suffer involution. **In the case of Man** any difference in their relative size on the two sides is by no means evident.

In two of the cases which the author has examined, the **occipital lobe** presented an abnormality. In one of them the occipito-parietal fissure was much deeper and wider than usual; in the other there was a distinct cross furrow in the neighbourhood of the third occipital convolution. In both, the abnormality was bilateral, and hence may have been accidental. There did not appear to be any degeneration of underlying parts.

A question comes to be whether mere **physical inertia** of the retina from opacity of the media in front of it will occasion an ascending degeneration. Certain cases of cicatricial opacity of the cornea acquired in childhood seem to favour the view that it does. In these the nerve is sometimes smaller than that on the opposite side. Recovery of vision, however, takes place after old-standing cataract, a fact which would point in the opposite direction. In ordinary cataract, however, the lens is seldom impervious to light, and the disease usually occurs in old people.

v. Gudden has shown that the atrophic changes following excision of the eyeball are more readily induced in young than in old animals.

EFFECTS OF DIVISION OF THE OPTIC NERVE, CHIASMA, AND TRACT.

949. The chief effect of division of the **optic nerve** is complete blindness in the corresponding eye, with loss of the pupil and other reflexes connected with vision.

When the **tract** is injuriously pressed upon or divided, say at B (Fig. 461), the direct fibres of the same eye and the crossed of the opposite eye are severed. The result is that the outer aspect of the retina on the same side and its inner aspect on the crossed side are paralysed. These areas of the retina are functionally homonymous. The term **hemiopia** is employed to designate this paralysed state of the retina; that of **hemianopsia** to indicate the resulting dark half of the field of vision. The hemianopsia is interpreted by the subject of the disease as being on the side opposite to that in which the hemiopia exists.

Thus if the left tract be the one affected, and consequently the left areas of the retina paralysed, the right half of the field of vision is that which appears unilluminated. The same holds good of other varieties of paralysis of the retina. Thus temporal hemiopia or paralysis of the outer halves of the retina excites nasal hemianopsia, and *vice versâ*.

Where the hemiopia affects parts of the retinæ which act in functional harmony, the term "homonymous" is applied to it; where the parts do not functionally correspond, that of "crossed" is used to indicate the condition.

The optic tract is probably the only part of the conducting apparatus which, when divided, causes true homonymous hemiopia. The dark half of the field of vision is sharply separated from that which is illuminated by a more or less vertical line. When one **occipital lobe** is annihilated a somewhat similar state of the field of vision follows, but the line of separation is never so defined.

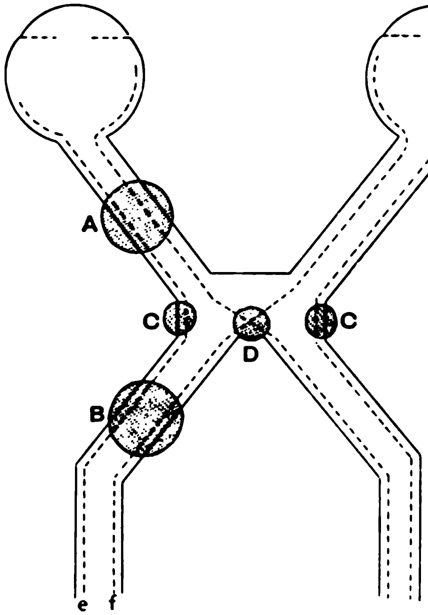


FIG. 461.—SCHEME OF DISTRIBUTION OF FIBRES OF THE OPTIC, TOGETHER WITH SITES OF VARIOUS LESIONS (see text).

The only other parts of the brain which occasion a hemiopic effect when destroyed are the **occipito-parietal band,** containing as it does the optic fibres from the occipital region, and the **posterior extremity of the thalamus.** In both cases the explanation of the hemiopia is to be found probably in the optic line of communications with the cortex being interrupted. It is seldom that the lesion of the thalamus in such cases is sharply localised; the sensory fibres lying in the neighbourhood are usually implicated, and hemianæsthesia follows.

When the **chiasma** is divided in the **middle line,** in an animal with incomplete decussation of the nerve, the sense of vision is not entirely lost (Nicati).

If it is destroyed say by the pressure of a tumour on **either side** at C C, the direct bands are severed. The outer aspects of each retina are consequently rendered blind, and this induces a **double temporal hemiopia** or **double nasal hemianopsia.**

When the destruction takes place **over the chiasma** at a point D, **double nasal hemiopia** results—that is to say, both inner parts of the retina are rendered blind, parts which functionally are not homonymous. This is interpreted as a **double temporal hemianopsia.** Images become superimposed, and as an effect there is confusion of vision mostly experienced in walking.

EFFECTS OF DESTRUCTION OF THE OCCIPITAL LOBES.

950. As already mentioned (Sect. 922), there are two main views regarding the cortical localisation of visual impressions; the one that the occipital lobes are the seat of their reception, the other that the angular gyri, in the monkey at least, are also concerned. It is to be borne in mind that effects alike with those resulting from destruction of the occipital lobe are forthcoming when the fibres issuing from this lobe, and which are contained in the occipito-parietal band, are cut across. The occipito-parietal band, as will be seen by referring to Fig. 445, lies very close to the cortex and immediately under the angular gyrus. Hence injury of this gyrus, if at all deep, would be certain to implicate the band and to occasion effects which are apart from the true function of the gyrus itself.

Whatever the real state of the case may be, no one can peruse the accumulated literature on the subject of lesions of the occipital lobes without being convinced of the primary importance in Man of the occipital lobes as receptacles for the storing of visual memories.[1]

The lesions of vision resulting from cortical destruction may be unilateral or bilateral, complete or incomplete, but there is always one feature associated with them, namely, that they are homonymous.

Cortical Blindness and Psychical or Mental Blindness.

951. These two terms are employed to indicate certain visual defects resulting from lesion of the occipital lobe or lobes.

---

[1] An excellent collection of such cases is to be found in a paper by Reinhard (No. 517, xvii. 1886, p. 717 *et seq.*). Curiously, in some of the cases he refers to, the angular gyrus and other portions of the parietal lobe were implicated simultaneously with the occipital lobe. In these cases the resulting hemianopsia was complete.

By **cortical blindness** is meant paralysis of the retina, resulting from destruction of the cerebral cortex. By **psychical blindness** is understood the obliteration of the visual memories gained during the individual's life experience.

Each of these may be complete or incomplete. Thus the retina may be paralysed in homonymous halves from a cortical lesion, the result being incomplete cortical blindness, or what is termed *cortical hemiopia*. Or the retina may be completely paralysed from cortical causes, so that the individual is insensitive through vision to all external impressions. Cortical blindness differs from blindness induced by destruction of the optic nerve in the fact that the ordinary reflexes of the pupil remain while the individual may be perfectly blind.

Word-blindness is sometimes said nowadays to be simply a variety of psychical blindness. This, as previously explained (Sect. 671), is manifestly incorrect. What is wanting in word-blindness is the faculty of translating the visual impression received from the written or printed symbols into their corresponding sound-memories. The power of rousing up the auditory memory, by which alone they come to be intelligible, is lost. Neither the auditory centre in the temporo-sphenoidal lobe nor the visual centre in the occipital need be destroyed to induce this, but the lesion must evidently lie, for reasons before described, in the link of connection between the two—that is to say, somewhere in the neighbourhood of the convolutions bordering upon the base of the temporo-sphenoidal lobe. It is quite possible that, as sometimes happens, the lesion might extend back as far as the occipital lobe itself. In such cases, however, other effects such as cortical hemiopia would most likely be present, and hence the case would not be one of pure word-blindness.

It may be questioned whether true psychical blindness can exist without a corresponding cortical paralysis of the retina. Is it possible, for instance, that certain visual memories may be obliterated without vision being impaired, or do they always go hand in hand? When the occipital region in a dog is excised the animal heedlessly knocks itself against objects which, in its normal state, it would have avoided. It behaves in such a manner that its condition might be interpreted as caused by impaired or lost memory of the meanings of such objects—that is to say, the animal might be regarded as psychically blind. It is quite possible, however, that all these phenomena are to be accounted for by the retina being partially paralysed.

The nearest approach to a pure psychical defect of vision, in all probability, is *colour-blindness* either of congenital origin or acquired.

Psychical blindness in its minor degrees is said by Reinhard (No. 517, xviii. 1887, p. 449) to result from superficial lesions of the occipital cortex, it may be without any cortical blindness. Cortical blindness, on the other hand, is noticed oftener where the lesion, in addition to destroying the cortical gray matter, extends so deeply as to involve the underlying white.

Munk (No. 552) was of opinion that the fibres issuing from different localities of the occipital region in the dog innervated areas *corresponding in position* within the retina. This is, however, somewhat difficult to substantiate in the case of Man.

Reinhard (*loc. cit.*) alleges that in Man the second occipital convolution innervates the macula lutea, and represents the point from which those fibres are projected most intimately connected with vision.

Literature on Abnormalities of Vision connected with Central Lesions.—**Bechtereff (V.)** (Perception of Visual Objects): Arch. f. Psychiat., etc., Charkov, xv. 1890, p. 1. **Berger** (Cortical Centre for Vision): Breslau. aerztl. Ztschr., viii. 1885, pp. 28, 37, 51. **Bernheimer:** Ueb. d. Sehnervenwurzeln des Menschen; Ursprung, Entwickelung, u. Verlauf., 1891. **Brown and Schaefer** (Occipital and Temporal Lobes of Monkey's Brain): Phil. Trans., clxxix. 1889, p. 303. **Christiani:** Zur Physiologie des Gehirns, 1885. **Damsch** (Unrest of Pupils and Cerebral Disease): Neurol. Centralbl., ix. 1890, p. 258. **Darkschewitsch** (So-called Primary Optic Centres): Arch. f. Anat. u. Entwicklngsgesch., 1886, Anat. Ab., p. 249. **Delépine** (Hemiopia from Occipital Lesion): Trans. Path. Soc. Lond., 1890. **Donaldson** (Visual Area in Laura Bridgman's Brain): American Journ. of Psychol., iv. No. 4, Aug. 1892. **Féré** (Visual Centre): Arch. de neurol., ix. 1885, p. 222. **Ferrier:** Brain, xi. 1888, p. 7. **Freund** (Optic Aphasia): Arch. f. Psychiat., xx. 1888-89, p. 371. **Hebold** (Crossing of the Optics in Man): Arch. f. Ophthal., xxxviii. 1892, 1 Ab., p. 221. **Henschen** (Visual Path. and Centre): Brain, lxi. and lxii. 1893, p. 170. **Loeb:** Arch. f. d. ges. Physiol., xxxiv. 1884, p. 76. **Moeli:** Arch. f. Psychiat., xxii. 1890, p. 73. **Monakow** (Cortical Experiments on Animals and Observations in Man): Arch. f. Psychiat., xiv. 1883, p. 699; *also, Ibid.*, xx. 1888-89, p. 714. **Munk** (Visual Area of Cortex): Brain, xiii. 1890, p. 45, *Transl.* **Nieden** (Slough of Occipital Lobe in Man): Arch. f. Ophthalmol., xxix. Ab. 3, p. 143. **Reinhard** (Visual Centre): Arch. f. Psychiat., xvii. 1886, p. 717; *also, Ibid.*, xviii. 1887, pp. 240, 449. **Schaefer** (Visual Area): Brain, xi. 1888-89, p. 1; *Ibid.*, p. 145. **Schweigger** (Hemiopia): Arch. f. Ophthal., xxii. Ab. iii. p. 276. **v. Schulten** (Brain Pressure and Circulation in Eyeball, Experimental): Arch. f. klin. Chir., xxxii. 1885, p. 455. **Schulz** (Unilateral Temp. Hemianopsia Sinistra): Arch. f. Psychiat., xvi. 1885, p. 579. **Shaw** (Lesion of Angular Gyrus): Brain, v. 1883, p. 255. **Siemerling** (Gumma of Base of Brain involving Chiasma): Arch. f. Psychiat., xix. 1888, p. 401. **Starr** (Analysis of Thirty-two Cases): Brain, vii. 1885. **Thompson and Brown** (Centre for Vision): Research Loomis Lab. . . . Univ. City, N. York, 1890, p. 13. **Willbrand and Saenger:** Ueb. Sehstörungen bei functionellen Nervenleiden, 1892.

THE COLOUR-SENSE AND COLOUR-BLINDNESS.

952. The centres for the perception of colour and space are now usually localised in the occipital lobes. Willbrand even asserted that the parts of the occipital lobe for the perception of light, colour, and space are arranged one over the other.

There are very few individuals who are totally colour-blind or achromatopic. When an individual is quite colour-blind the spectrum appears uncoloured, although there are differences in brightness at different parts, the brightest being in the situation of the green-yellow. There are generally said to be three forms of the affection, although some observers deny that there is more than one. They are known as (1) red-blindness; (2) green-blindness; and (3) violet-blindness. Dalton suffered from the first of these, and hence the affection is usually called Daltonism. Bright red and dark green are confounded. Blood appeared to him to resemble a bottle-green, and he could not distinguish between the colour of a ripe cherry and the surrounding foliage. He was able to detect only two, at most three, colours in the spectrum. As Clerk Maxwell demonstrated, the spectrum in this and other varieties appears dichromatic, yellow and blue being the two colours which are perceived. The red and green are absent, while the violet end of the spectrum is lost in the blue. In Dalton's case the yellow comprehended the red, yellow, and green of others, but his blue coincided with theirs. That part of the spectrum which others call red appeared to him little more than a shade or defect of light, and the succeeding orange, yellow, and green seemed one colour. This is what is usually noticed.

In so-called green-blindness bright green and dark red appear identical. The yellow of the spectrum lies close on the blue, or they are separated only by a gray band.

In the blue-yellow variety, if it exist, vision is said to be again dichromic; the colours which are perceived are red and green. The blue-violet end of the spectrum is much shortened.

Colour-blindness is sometimes unilateral. As a rule it is a concongenital defect, but may follow in the wake of cerebral disease, or manifest itself in those with incipient disease of the optic nerves, such as that which occurs in locomotor ataxia. It may be induced by various toxic substances, such as tobacco when taken to excess.

Colour-blindness occurs in about 4 per cent of men with vision which is otherwise normal. It is ten times as frequent in men as in women.

Colour-blind individuals, although never to be trusted in any employment where absolute distinction between two colours, such as red and green, is essential, get along wonderfully well notwithstanding their defect. The reason is that they usually see a difference in the luminosity of two bodies, coloured say red and green. A colour is possessed of three qualities—(1) *hue* or tint, as when we speak of red, green, or violet; (2) *purity* or degree of saturation (due to a greater or less admixture of white); and (3) *brightness*, intensity, or luminosity, as when we describe the tint of a red rose as dark or bright (M'Kendrick). Hence in the testing of an individual we should take care that the luminosity of the two test colours is as nearly as possible alike, otherwise the individual may be able to distinguish between them. Even although a person is red-blind, he may in ordinary circumstances be able to recognise the red or green of a signal lamp, from the fact that the red glass employed in the manufacture of signal lamps has a distinct tinge of yellow, while the green glass is contaminated with blue. The pure colours of the spectrum are alone strictly reliable. In the ordinary testing for colour-defect, however, coloured skeins of worsted (Holmgren) are usually employed. These must be of the same illuminative power, and the colours used in dyeing them must be eliminated from all traces of yellow or blue. The individual under examination is given a skein of green or red worsted and is asked to pick out from a mixed lot of others differently coloured those colours which most closely match the colours chosen. If colour-blind, and if green is the colour selected, he invariably picks out the red, and *vice versâ* if the colour selected be red.

The two theories of colour-vision which for long held the field, and still to a certain extent retain it, were respectively those of Young and Helmholtz, and of Hering.

Young-Helmholtz Theory.—This, which is essentially the theory of Young (see Bibliog.), presupposes that colour sensations depend upon the stimulation of three different sets of fibres in the retina. The stimulation of a single set gives rise to the sensation of red, green, or violet respectively, while all other colours are simply combinations of these. The sensation of blue, for instance, would be called forth by the simultaneous stimulation of the green and violet. The excitation of any one set of fibres is dependent upon a matter of wave-length. Those waves which are longest excite the red fibres, those which are intermediate in length are appreciated by the fibres conveying the stimulus giving rise to the sensation of green, while the shortest waves affect the fibres which call forth the sensation of violet. The explanation of colour-blindness afforded by this theory is that in the retina of the colour-blind individual there is a defect whereby the particular nerve filaments for the reception of light vibrations giving rise to the sensation of red, green, or violet are absent; that the defect in reality is one of the retina.

Aitken (No. 623, viii. 1873, p. 389) is also a believer in the three-nerve theory. The three primary colour sensations, he asserts, are red, green, and violet; that is to say, they are incapable of being decomposed, or of being called forth by a combination of any two or more other colour sensations. The three sets of nerves are the means of conveying the impressions necessary to excite these colour sensations, and the only thing we can distinguish by these nerves *separately* is *intensity*. The red nerve gives us the sensation only of red in a greater or less degree, the green nerve that only of green, the violet nerve of violet. He alleges that each set of nerves is thus comparable to our heat nerves, capable of detecting intensity only. If we had only one set of nerves in the eye, we could have but one kind of sensation when light falls upon it, and the light from different objects would differ only in intensity. This theory explains why yellow and blue can be produced by mixing the colours in the spectrum on each side of them, while neither red, green, nor violet can be produced by any mixtures.

The secondary colour sensations such as yellow and blue are compounded of two primaries, and are due to the range of sensibility of two of the above nerves partially overlapping. Thus yellow is the result of the red nerve being partially sensitive to vibrations which also excite the green. The red nerve is not only capable of appreciating and conveying the vibrations at the extreme end of the spectrum which occasion the sensation of pure red, but also of those which lie intermediate between the red and the green; while the green nerve similarly can convey vibrations not only corresponding to the area of green in the spectrum, but also of those which lie between the red and the green. The result of this double sensation is the production of the compound or secondary colour sensation, *yellow* having its point of greatest intensity midway between the red and the green. In a like manner he accounts for the *blue*. It is essentially a compound sensation made up of green and violet, and is due to the overlapping of the range of sensibility of the green and violet nerves.

Among other possible causes of colour-blindness he admits the following: (1) That the sensations of two of the three above-referred-to nerves is the same. (2) That the nerves, instead of appreciating only those light vibrations of the particular wave-lengths which give rise in the normal eye to the sensations of red, green, and violet respectively, are so constructed that they possess a wider range of sensibility. Thus the red nerves might be sensitive to all the rays to which the green nerves are sensitive, and the green nerves similarly to all the rays to which the red nerves are sensitive. Suppose that any of the rays of the spectrum from the red to the green fall upon two sets of nerves so related, both would be excited throughout their entire range, and the sensation produced would be what we call *yellow*. The nerves might individually be conveying the sensations of red and green, and yet the person might actually never know the sensations of these colours, because neither of them had been excited separately. (3) That one set of nerves is wanting.

Hering's Theory.—This alternative theory is essentially one of contrast colours. Hering maintains that the primary visual sensations are white, black, red, yellow, green, and blue, and further that they may be arranged in three pairs in the above order, the one colour complementary to the other—white to black, red to green, yellow to blue. The phenomena which lead to the assumption of the association of the fundamental colours in pairs are those connected with colour after-images, and the fact that the colours which are arranged in pairs mutually neutralise each other. Thus we find in Nature that a colour cannot be seen as red and green simultaneously. We have no knowledge of a reddish-green colour, whereas the colours from different groups may be readily enough associated. We are familiar, for instance, with what is meant by a bluish-green or a yellowish-green, and a red which inclines either to yellow or blue. Hering's hypothesis, moreover, assumes the presence within the retina of visual substances which are constructively or destructively influenced by waves of varying length. These substances are probably three in number; one for red-green, another for yellow-blue, and a third for white-black. Thus when a ray of a particular wave-length falls on the retina it induces metabolic changes in one of the visual substances of a constructive nature, while a ray having a different wave-length has the effect of exciting changes of a destructive nature. Those changes which give rise to the sensations black, green, and blue are processes of assimilation or construction; those which occasion the sensations of white, red, and yellow are processes of dissimulation or destruction. When a wave of a particular length acts upon the substance concerned with the red-green sensation it induces a destructive or katabolic action within it, and the sensation is interpreted as red; when a light wave of shorter length falls upon it the resulting metabolism is constructive or anabolic, and the sensation is interpreted as green. When the entire rays of the spectrum alight upon the retina, the one neutralises the other, but as the white-black substance is stimulated destructively under these circumstances, the sensation is interpreted as white. The two processes of constructive and destructive mechanism are apparently in constant action in the normal eye.

According to this theory, the commonest form of colour-blindness, namely, the red-green, is caused by the red-green substance being absent. Coloured after-images, as the complementary green following exposure of the retina to bright red, are to be explained by the visual substance having been destructively affected to begin with, and a constructive action having set in afterwards. The same holds good with yellow and blue, and white and black.

Edridge Green's Theory.—All these theories, however, presuppose that the essential defect is in the retina. From what we now know of the visual centre in the brain, it seems quite as likely, if not more so, that the vice is located in the apperceptive centre—that, in fact, colour-blindness is essentially a disease of interpretation, not one which is bound up with the mechanism placing the visual centre in communication with the periphery; that it is, in fact, simply a form, and probably a very pure one, of congenital psychical blindness.

Edridge Green in his fascinating work on the subject of colour-blindness (No. 579) has taken this view of the matter. His explanation of the colour sense is as follows:—

Suppose a large number of regularly-shaped bodies, spheres let us say, all differing in size, but very finely graduated, were placed in consecutive linear series, the greatest **points of difference** in the series would be at the beginning and the end. The next greatest point of difference would be in the centre of the series; and the next again would be midway between the middle point and either end, and so on. He holds that the different colours are due simply to points of greatest difference in the wave-lengths of a dispersed ray of light. The whole matter is one of interpretation.

A dispersed ray of sunlight constitutes an almost perfect physical series. The sensations of colour which it calls forth are due to the difference in the wave-lengths of its vibrations. Those vibrations which excite the sensation of red are the longest, and are placed at one end of the spectrum; while those which call forth that of violet are the shortest, and are placed at the opposite end of the spectrum.

There are vibrations beyond these points which excite neither the sensation of light nor that of colour, and hence fail to be perceived through the sense of vision. The vibrations of the extreme red rays take place at the rate of 395 billions per second; those of the extreme violet at the rate of 763 billions per second. Let A B (Fig. 462, I.) represent the physical light series; *a* and *b*, being the end members, represent therefore the points of greatest difference. The third point of greatest difference will be in the middle of the series, namely at *c*. The fourth at *d d*, and so on.

A normally-constituted individual on looking at the spectrum of sunlight can recognise six colours—that is to say, he is possessed of hexachromic vision. They are red, orange, yellow, green, blue, and violet. Supposing that the area of any one of these colours be examined through a narrow slit in a dark screen, it will be found that it is apparently made up of a series of monochromatic bands (*a*, *b*, *c*, etc., Fig. 462, III.) or what he calls *absolute psycho-physical units*; while to the whole series (A B) of any one colour, say of the green, he applies the term *approximate psycho-physical unit*. An absolute psycho-physical unit is thus made up of a series of waves whose length is such that no difference can be perceived between them. *a a′* (Fig. 462, II.) represents an absolute psycho-physical unit at the end of the violet, *b b′* at the end of the red. The points *a* and *b* are still the two points of greatest difference, although an observer would choose the

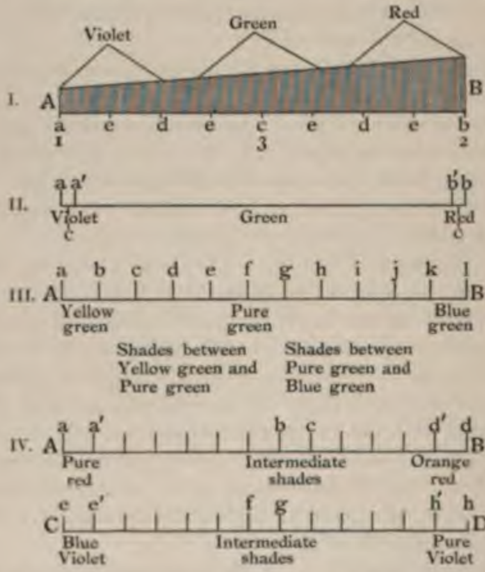


FIG. 462.—SCHEMES TO ILLUSTRATE EDRIDGE GREEN'S THEORY OF COLOUR-SENSE.

points *c c*. The approximate unit green is called green because the absolute units within it are more like green than they are like yellow or blue; the similarity is greater than the dissimilarity. On looking at any of these absolute psycho-physical units dissociated from those adjacent, the observer could not say which was the yellow and which the blue side, because they approach to absolute monochromatism. We can have a monochromatic patch of yellow-green as well as of pure green. In the case of the green, however, the central unit is theoretically and actually that which is representative of the pure colour. In the case of the red and the violet this is not so. The unit of purest colour in the red should be theoretically *a*, *a'*, and in the violet *h' h* (Fig. 462, IV.). They are the psycho-physical units adjacent to the real (physical) points of difference. An observer, however, might found his idea of red upon the unit *b c*.

Coming now to apply this theory of colour-perception to the explanation of the phenomena of colour-blindness, it is evident that all the possibilities of that affection might be explained on the basis of personal variation in the apperceptive power of each individual.

Firstly, a person may be totally wanting in the power of perceiving colour; he is perfectly achromatopic, and the spectrum to such an individual appears simply brighter or darker according to the intensity of the light.

Secondly, the perception of colour may not be so defective, the individual being able to perceive a few colours, although not the whole range perceptible to a normally-constituted person. Thus if the perception of colour be not so defective, the extremities of the spectrum will appear feebly tinted with red at one end and violet at the other; while the part intermediate will appear gray. As perception improves, the colours at the ends will tend to approach each other, while the gray interval will be gradually absorbed. They will ultimately meet, and the individual's colour-perception will then become dichromic. In such a case the impression of greatest intensity or the greatest point of difference in the two groups of units will be midway between each end of the spectrum and its centre—that is to say, in the situation of the yellow and the blue-violet rays respectively, and will fade off from this on either side.

As a matter of fact, a colour-blind person belonging to this class, on looking at the spectrum of sunlight, generally describes it as made up of two colours—yellow and blue. The one gradually passes into the other, and the intensest portion of each finds its counterpart in the yellow of the buttercup and the blue-violet of the corn-flower.

The next step will be the perception of another point of difference, and this will be located at the centre of the series—that is to say, in the midst of the green. Such a person will be trichromic, and the colours which he will appreciate will be red, green, and violet.

A further subdivision will take place in each of the halves of the spectrum, between either end and the central point; and as the waves are longest at the red end, the new point of difference will appear first between the red and the green, namely, in the position of the yellow. In the same manner the next point of difference to appear will be situated between the green and the violet, namely, in the position of the blue.

The sixth point of difference will appear on the red side of the fourth, namely, in the position of the orange. The seventh point of difference will be located between the green and the violet—that is to say, there will be two points of difference, or colours, seen between the green and the violet instead of one. The series might be extended *ad infinitum*, but as no one appears to be able to appreciate more than seven colours in the spectrum, it is needless to follow the argument further.

Literature on Colour-Blindness.—**Abney**: Journ. Soc. Arts, xl. 1891-92, p. 676. **Burnett**: Arch. Ophth. N. Y., x. 1881, p. 1; *also*, Reprint. **Cohn**: Studien üb. angeborene Farbenblindheit, 1879; *also*, Berl. klin. Wochnschr., xviii. 1885, p. 265. **Donders**: Ann. d'ocul., Brux., xxiii. 1850, p. 127: *also*, Brit. Med. Journ., 1880, ii. p. 767. **Fick**: Arb. a. d. physiol. Lab. d. Würzb., iii. 1876, p. 213. **Hart**: Brit. Med. Journ., 1869, i. p. 46. **Helmholtz**: Verhandl. d. naturh.-med. ver. zu Heidelb., 1859-62, ii. p. 1. **Holmgren**: De la cécité des couleurs dans ses rapports avec les chemins de fer et la marine; *Transl.* from Swedish, 1877; *also*, Die Arbeiten des Herrn Prof. Cohn üb. Farbenblindheit, 1879. **Jeffries**: Colour-Blindness; its Dangers and Detection, 1879; *also*, Lancet, 1880, ii. p. 7; *Ibid.*, p. 891; *also*, Journ. Nerv. and Ment. Dis., N. Y., vi. 1881, p. 433. **Leber** (in Disease of the Eye): Berl. klin. Wochnschr., vii. 1870, p. 8. **M'Gillivray** (Central Colour Defect): Brit. Med. Journ., 1892, ii. p. 178. **Mackay** (Quantitative Estimation of Colour Sense): Brit. Med. Journ., 1892, ii. p. 626. **Magnus**: Arch. f. Ophth., xxiv. 1878, p. 171. **Mauthner**: Allg. Wien. med. Ztg., xxiv. 1879, p. 491. **Nettleship** (in Disease of Optic Nerve): Brit. Med. Journ., 1880, ii. p. 779. **Poles**: Trans. Roy. Soc. Edin., xxxvii. 1893, Pt. II. p. 441. **Preyer**: Centralbl. f. d. med. Wissensch., xix. 1881, p. 1. **Rose** (in Santonin Poisoning): Arch. f. path. Anat., xix. 1860, p. 522; *Ibid.*, xx. 1861, p. 245. **Royal Society of London, Report on,** 1892. **Rutherford**: Nature, xlvi. 1892, p. 342. **Stilling**: Ueb. Farbensinn u. Farblindheit, 1878. **Wolfe**: Med. Times and Gaz., 1879, i. pp. 372, 419. **Wright**: Nineteenth Century, xxxi. 1892, p. 648. **Young**: Phil. Trans., 1802, pp. 12 and 387.

MECHANISM OF THE PUPIL REFLEXES ELICITED BY LIGHT.

953. The condition of the pupil is of the greatest diagnostic importance in cerebral pathology. It is to be borne in mind that differences in size of the pupil may be induced either by spasm or paralysis of its respective muscles. Contraction, for instance, may be the result either of spasm of the sphincter or paralysis of the dilator pupillæ. The sphincter pupillæ is controlled by the third nerve, the dilator by the sympathetic and the fifth.

The reflexes of the pupil called forth by light are two, namely, contraction on exposure to a bright light, and dilatation on removal to a dull light. The former is brought about by contraction of the sphincter pupillæ, the latter by contraction of the dilator.

The reflex arc concerned with **contraction of the sphincter** is usually said to be along the optic nerves and tracts to the anterior corpora quadrigemina, thence to the underlying nucleus of the third nerve on the floor of the aqueduct of Sylvius, and along the third nerve itself to the iris. As the third nerves decussate extensively across the middle line, a stimulus from one eye causes contraction of both pupils.

Of late years, this reflex connection has been called in question. Bechterew (No. 511, xii. 1884, p. 57), from experiments made upon dogs and birds some years ago, concluded that the reflex arc for the contraction of the pupil to light is not that usually accepted. The ingoing tract, he holds, runs by way of the optic nerve up to the chiasma, thence to the gray matter lining the third ventricle, and continuously onwards from this along the floor of the aqueduct to the nucleus of the third nerve.

There are several bundles of fibres communicating with the optic above the chiasma. One of these is **Meynert's commissure** (Sect. 947). Whether this is concerned in the above reflex or not is still unsettled. Should it turn out that Bechterew's notion is true it can easily be understood how alterations of brain pressure might induce stimulation or paralysis of these bundles of fibres. They lie embedded in the lamina cinerea and adjacent gray lining of the third ventricle, so that any increase of the pressure of the liquid within the latter would injuriously affect them (see *Brain Pressure*, Sect. 905).

The fibres concerned with **contraction of the dilator** can be traced to two sources. One of these is the sympathetic, arising from the spinal cord in the neighbourhood of the seventh and eighth cervical and the first and second dorsal spinal nerves, the so-called **cilio-spinal centre of Budge** (No. 556). Another is from the fifth nerve. The evidence in favour of the sympathetic fibres connected with the dilator pupillæ being derived from this part of the cord is that destructive lesions of the above cilio-spinal region are known to cause **myosis** or contraction of the pupil, from paralysis of the dilator fibres; while irritative affections of the same part of the cord induce **mydriasis** or dilatation, from stimulation of the same.

CENTRE FOR REGULATION OF THE PHENOMENA CONNECTED WITH ACCOMMODATION.

954. The third nerve is evidently that which is concerned with the act of accommodation, the narrowing of the pupil, and the convergence of the eyeballs necessary for examining a near object. Fibres of this nerve pass into the ciliary ganglion, which subsequently are distributed to the ciliary muscle, the sphincter of the pupil, etc.

According to the experiments of Hensen and Völckers (No. 518, xxiv. Ab. I. 1878, p. 1), the movements of accommodation are quite independent of the corpora quadrigemina. The centre which regulates them, like that concerned with light reflexes, appears to lie on the **floor of the third ventricle and aqueduct**.

They find, when the cerebral hemispheres in the narcotised dog are more or less completely, and the corpora quadrigemina completely removed, so as to expose the gray matter of the floor of the third ventricle and aqueduct, that, on stimulating the floor of the third ventricle immediately over the corpora mammilaria, close to the middle line, with a weak induction current, movements of accommodation (tensor choroideæ) are elicited. Contraction of the iris is induced by the application of the electrodes a little farther back; that of the rectus internus by stimulation of the border zone between the aqueduct and the third ventricle. Then follow in respective order the areas controlling the rectus superior, the levator palpabræ superioris, the rectus inferior, and lastly the obliquus inferior.

CENTRE FOR LATERAL MOVEMENTS OF THE EYEBALLS.

955. The movements of convergence of the eyeballs induced by stimulation of the floor of the aqueduct, it should be remembered, are quite independent of those concerned with conjugate contraction of the ocular muscles for the lateral movements of the eyeballs. In the former case, the two internal recti come into play, in the latter, the external rectus of the one eye and the internal rectus of the other. The centres for each set of movements seem to be apart, for while the one class of movement may be paralysed the other may remain.

It was supposed by Foville (No. 244, iii. 1858, p. 393) that the centre for the conjugate lateral movements of the eyeball resides in each abducens nucleus or its neighbourhood. A case is reported by Ferréol (No. 150, 1873, No. xlvii.) where a tubercle affecting the nucleus of the sixth was followed by paralysis of the rectus externus of the one eye and of the rectus internus of the other. The power of convergence was retained while the movements of monocular vision were free. Similar observations have been made by Wernicke (No. 517, vii. 1877, p. 513). Bennett and Savill (No. 521, xii. 1890, p. 102) report a case where a small area of hæmorrhagic destruction in the left abducens nucleus gave rise for a month before death to persistent conjugate deviation of the eyeballs to the right.

Experimental evidence also supports the view that there exists a co-ordinating reflex centre in this neighbourhood—that is to say, in the lower part of the pons. Laborde (No. 204, 1878, No. iii.) and Graux (No. 555) have shown that when the abducens nucleus is punctured in an animal conjugate movement of the eyeballs follows to the same side; and when it is destroyed a corresponding paralysis follows, with the eyes drawn to the opposite side.

OPHTHALMOPLEGIA.

956. The disease was first noticed by v. Graefe.[1] The patient, a man aged forty, in whom it occurred presented a complete paralysis of

---

[1] See Bibliog. for historical references.

all the twelve moto-ocular muscles with preservation of vision and power of accommodation.

Hutchinson's paper, published more than twenty years after v. Graefe's first contribution to the subject, drew especial attention to it in this country. The works of Buzzard, Bristowe, and more particularly the very thorough posthumous publication of Westphal, have done much to elucidate the pathology of this remarkable affection.

It commences usually with drooping of the eyelids, which is soon followed by weakness in all the muscles influencing the position of the eyeball, so that the movements of the eyeball are either restricted or lost. It is commonly a bilateral affection, but has not necessarily advanced to the same degree on both sides. The paralysis, however, spreads among *groups* of muscles. The disease may be accompanied by locomotor ataxia, Graves' disease, hemiplegia, wasting palsy, etc.

Westphal (No. 517, xxii. 1891, Suppl. Hft., p. 127) found in his cases that the lesion affected either (1) *the nuclei of the oculo-motor nerves*, or (2) *the nerve trunks in their intramedullary course*. The former is the commoner of the two causes, and when it is present the fibres issuing from the nuclei are, as a rule, simultaneously diseased. In the case of the abducens and the oculo-motorius the lesion of the nucleus is usually bilateral. In some cases the cells have gone; in others they are shrunken and devoid of processes, the nucleus is indistinct, and vacuoles are occasionally present in the cell protoplasm. In two of Westphal's cases there was pigmentation of the trochlearis nucleus. The fibres tend to fall to pieces. There is no particular disease of the walls of the vessels, nor are there hæmorrhages into the nerve nuclei. The glia-tissue from which the nerve cells and fibres have disappeared is rich in connective tissue cells, especially in spider cells, which often form a thick felt-work. The process of degeneration appears to be one which is primary in the ganglion cells. They seem to vanish simply by shrinkage. The muscles affected lose in bulk.

The fact that the oculo-motor muscles may be paralysed separately or in groups would point to the likelihood of the nucleus of the third nerve being segmented. Darkschewitsch (No. 51, 1889, p. 107) states that running on either side of the floor of the aqueduct of Sylvius and beneath the anterior corpora quadrigemina there are two groups of cells arranged in columns. They are quite separate. The lower is undoubtedly the classical nucleus of the third nerve, and he holds that the upper must also be reckoned as appertaining to this nerve. The two nuclei, however, differ in character, particularly in regard to their cells. Those in the upper nucleus are small, those in the lower large.

As previously described (p. 705), Hensen and Völckers have attempted to arrange the various subdivisions of the third nucleus, from experimental evidence, in the following order from before backwards :—

(1) Accommodation (tensor choroideæ).
(2) Sphincter iridis.
(3) Rectus internus.
(4) Rectus superior.

(5) Levator palpabræ superioris.
(6) Rectus inferior.
(7) Obliquus inferior.

Bruce (No. 189, xvii. 1889-90, p. 168) has also attempted the same on anatomical grounds. From the histological examination of the third nucleus in the fœtus and in the adult he concludes that it may be subdivided in the following manner: (1) an anterior group; (2) a postero-external group; (3) a median nucleus; (4) a postero-internal nucleus; and (5) a superior nucleus. Without expressing any positive opinion as to their functions he thinks it likely that the inferior, anterior, and postero-lateral (including the external) groups of nuclei are connected with the extrinsic muscles of the eyeball and the elevator of the eyelids; and that the median and the postero-internal nuclei are the centres for accommodation and contraction of the pupil.

Literature on Ophthalmoplegia.—**Bramwell** (Ophthalmoplegia): In his Atlas of Clin. Med., 1891, i. p. 122. **Bristowe:** Brain, viii. 1886, p. 313; *also* (Conjugate Deviation of Eyes from Tumour of the Pons), Brain, xiv. 1891-92, p. 289. **Buzzard:** Brain, v. 1883, p. 34. **v. Graefe:** Arch. f. Ophth., 1856, p. 299; 1866, p. 265; *also*, Berl. klin. Wochnschr., 1868, p. 126. **Hutchinson:** Med. Chir. Trans., Lond., lxi. 1878, p. 215; lxii. 1879, p. 307. **Sauvineau:** Pathogénie et diagnostic des ophthalmoplégies, 1892. **Westphal:** Arch. f. Psychiat., xxii. (Suppl. Bd.) 1891, p. 1.

Optic Neuritis.

957. **Causes.**—The importance of this as an indication of brain disease cannot be exaggerated. It is one of the most constant indications of **tumours** located in almost any part of the brain. It also accompanies **hydrocephalus** and **basal meningitis.** It is rare in abscess of the brain and in focal hæmorrhages.

The disease, however, is not always due to intracranial causes. **Orbital tumours, periostitis of the orbit,** etc., may secondarily affect the nerve.

It is also induced by certain general morbid conditions of the body, such as **typhus, measles, pneumonia, puerperal** and **scarlet fevers,** and more particularly **chronic Bright's disease.** Exposure to cold or the continued influence of a brilliant and concentrated light has been said to occasion it.

Forms.—There are said to be two varieties, one, where the disease commences in the brain and descends along the optic nerve to the retina, so-called *descending optic neuritis;* another, where the disease arises in the retina and in the nerve just as it enters the eyeball, the so-called *choke-disc form, engorged papilla,* or what is sometimes known as *ascending optic neuritis.*

Descending Optic Neuritis.

v. Graefe supposed that the starting-point of this was a meningitis. It is the form oftenest associated with tumours, and occasionally these certainly are accompanied by meningitis. This, however, will not explain all cases, for in a large proportion of instances of descending optic neuritis there is an absence of meningitis.

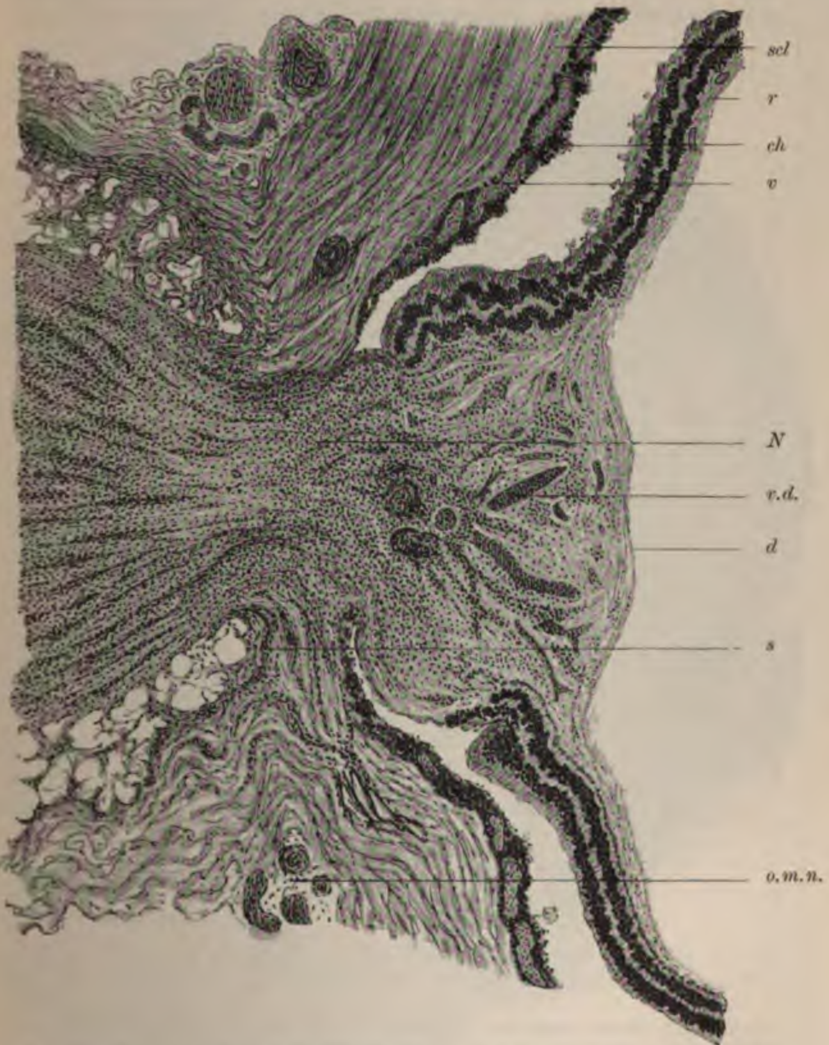


FIG. 463.—DESCENDING OPTIC NEURITIS FROM TUMOUR OF CEREBRAL HEMISPHERE SHOWN IN FIG. 465. SECTION THROUGH THE ENTRANCE OF THE NERVE (×40 DIAMS.)

(*scl*) Sclerotic comparatively free from any inflammatory infiltration; (*r*) retina, its various layers stained with the hæmatoxylene. It has become detached from the choroid (*ch*). (*v*) Engorged vessels of the choroid; (*N*) the nerve as it pierces the cribriform lamella. The small points seen in its substance are inflammatory cells. (*v.d.*) Engorged vessels of the disc; (*d*) the disc; (*s*) subarachnoid spaces in the sheath of the nerve distended with liquid; (*o.m.n.*) oculo-motor nerves (Hæmatoxylene, Eosin, and Clarified).

The sheath of the nerve is often distended with fluid, and the distension is greatest a short way beyond the eyeball. The connective tissue of the pial sheath and of the trabeculæ surrounding the bundles of nerve fibre becomes thickened and manifests an increase of its cells.

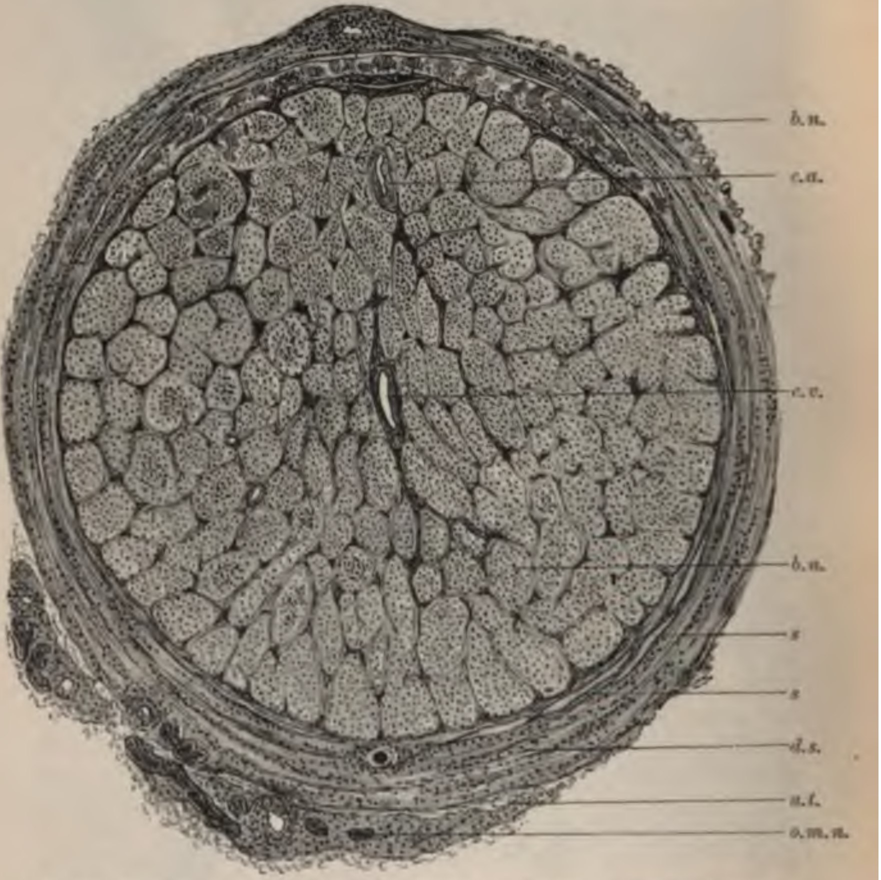


FIG. 464.—DESCENDING OPTIC NEURITIS FROM TUMOUR OF CEREBRAL HEMISPHERE SHOWN IN FIG. 465. TRANSVERSE SECTION OF THE NERVE A SHORT WAY ABOVE ITS POINT OF ENTRANCE (×40 DIAMS.)

(*b.n.*, *b.n.*) Bundles of nerve fibres. The dark points within them are inflammatory cells. (*c.a.*) Central artery; (*c.v.*) central vein; (*s.s.*) subarachnoid spaces; (*d.s.*) dural sheath; (*a.t.*) areolar tissue around the nerve; (*o.m.n.*) oculo-motor nerve (Hæmatoxylene, Eosin, and Clarified).

A like cellular increase can be noticed between the individual nerve fibres (Figs. 463, 464). The nerve fibres become irregularly thickened and present an unusually varicose appearance, while the medullary sheath becomes granular. In advanced cases the openings in the lamina cribrosa become distended and the tissue of the lamina itself is greatly altered.

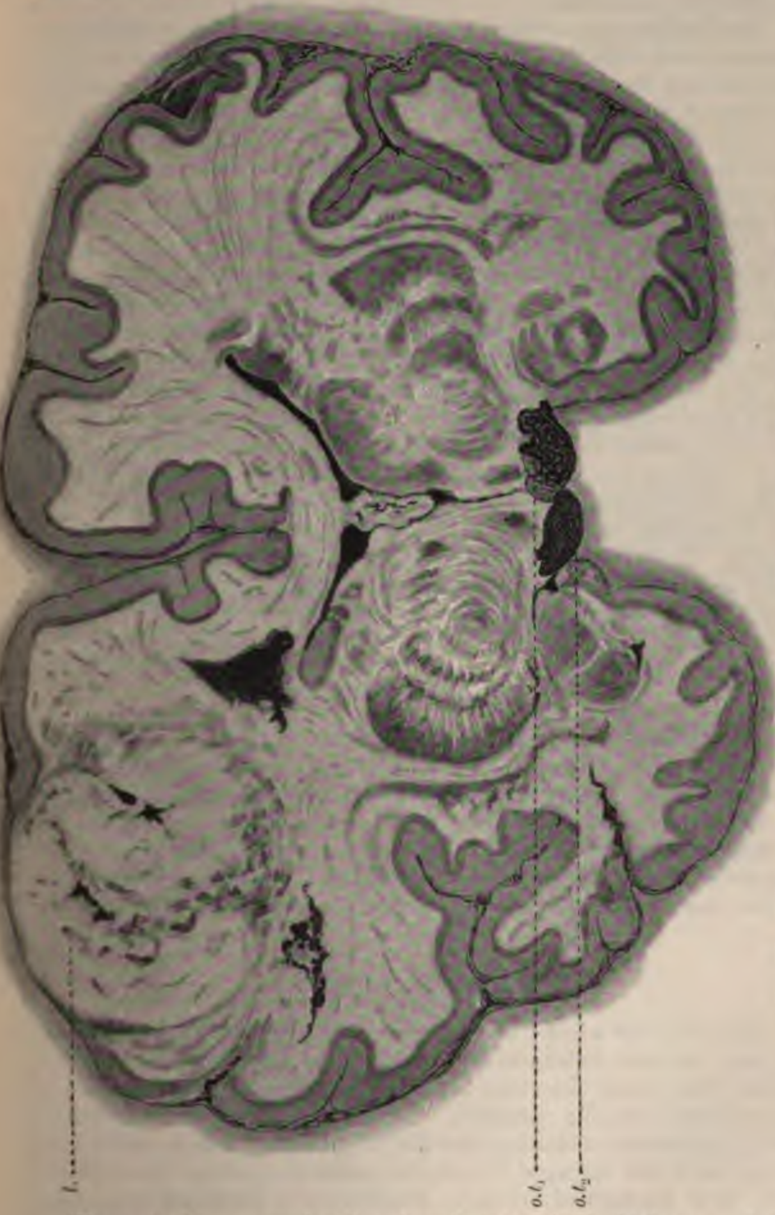


FIG. 405.—GLIOMATOUS TUMOUR OF LEFT CEREBRAL HEMISPHERE. SHOWS THE ILL-DEFINED BORDER.

(*t*) Points of softening in midst of tumour; (*o.t*$_1$) right optic tract peculiarly swollen; (*o.t*$_2$) left optic tract in a similar condition (hardened by being injected with Müller's fluid).

There is thus engendered a chronic interstitial thickening of the fibrous basis of the nerve, with, it may be, destruction of the nerve fibres. The condition would be named in other localities a cirrhosis or sclerosis of a nerve.

Its Pathology.—When we come to inquire how it is brought about, we meet with difficulty. There are possibly two circumstances which may account for it: (1) Either that the disease of the brain raises the pressure of the cerebro-spinal liquid within the cranium, and that this, through the free communication which exists between the two, reacts upon the liquid within the sheath of the nerve. This interferes with the circulation within the nerve itself and brings about a chronic inflammatory condition. (2) Or that, in the case of brain tumours at least, the disease is simply an extension downwards of the sclerotic condition of the brain, which almost always accompanies these tumours (see p. 577). It cannot be due invariably to increased brain pressure, because there are cases where from a tumour of a remote part of the organ the neuritis is confined to the eye of the same side.

The optic neuritis which follows upon tumours of the brain is quite independent of situation. It may be caused by a tumour located in almost any part of the organ. How is this to be accounted for? Were it due to a general cause, such as the increased pressure of the cerebro-spinal liquid, this peculiarity might be explainable. At the same time, it is to be remembered (Sect. 947) that the optic directly or indirectly is connected with almost every part of the cerebrum, and hence that a chronic cerebritis might very readily pass downwards from various localities into its trunk.

Ascending Optic Neuritis.

The choke-disc or engorged papilla form, so far as the part of the nerve immediately adjacent to the cribriform lamella and that within it are concerned, might be readily enough traced to increased pressure of the cerebro-spinal liquid. The vessels become more or less strangulated, with the result that the circulation through them is impeded. A chronic congestive state of the nerve and of its expansion in the retina is thus engendered with all its attendant evils.

Condition of the Retina.

The rosy tint which the disc naturally possesses is increased, and its edge becomes indefinite and more or less fused with surrounding parts. The whole disc may become so swollen that the natural or physiological cupping vanishes. It may in some cases present a woolly appearance radiating into the neighbouring retina. The veins are tortuous and engorged or varicose, while the arteries are indistinct from their diminished volume. Exudation in course of time takes place into the retina, so that the vessels as they turn over the edge of the disc are more or less completely buried in the effusion and are correspondingly obscured. Extravasations of blood may take place into the retina whereby portions of its texture are permanently destroyed.

One curious point is that the disease may have far advanced without vision being seriously impaired.

LESIONS OF THE CORPORA QUADRIGEMINA.

958. From what has just been said (p. 687) it is evident, in the first place, that the corpora quadrigemina have very little to do with the sense of vision, and that it is questionable even whether they are bound up with the ocular reflexes and with the function of associating the various eye muscles. Like the caudate nucleus, they appear to be structures which in a manner have become effete. The anterior pair are probably the homologues of the optic lobes of types low in the scale. As the brain increased in complexity, however, the functions formerly resident in them seem to have been transferred to other parts.

Disease localised within them is rare, but a tumour has been known to be resident within them for weeks or months without impairing or otherwise affecting vision, without even interfering with the combined action of the ocular muscles. The meagre evidence existing would tend to the belief that it is only when such tumours come to press upon the centres on the floor of the aqueduct that disorders of co-ordination are noticed.

CHAPTER LXXXIV

THE NERVOUS SYSTEM—(*Continued*)

THE SECONDARY DEGENERATIONS.

959. **Definition.**—By the term "Secondary Degeneration" is meant *that destruction of a nerve fibre which follows separation from its trophic nerve cell.* It is not dependent upon impaired blood-supply.

Historical.—Türck (No. 12, vi. 1851, p. 288; *Ibid.*, xi. 1853, p. 93; and *Ibid.*, xiv. 1855, p. 329) first gave a systematic description of these degenerations as seen in the cord, although the appearances characteristic of them had been noticed in the brain by Cruveilhier (No. 332, Liv. xxxii. p. 16) in the year 1832. About the same time that Türck was making his observations on the spinal cord in Man, Waller (No. 137, iv. 1852, p. 609) published his experiments upon the degeneration as it occurs in divided peripheral nerves of the lower animals. The excitation of secondary degenerations experimentally with the view of tracing the course of nerve tracts, or for other purposes, has come to be known consequently as the "Wallerian method of investigation."

SECONDARY DEGENERATION IN NERVE TRUNKS.

960. When a peripheral nerve is divided, or what is better, when a piece is excised so as to sever completely the continuity of the trunk, the peripheral part degenerates. Within forty-eight hours the **myeline** is seen to be somewhat broken up into globules. This becomes more evident by the seventh day, when fatty degeneration of the myeline drops is superadded. The **nuclei of the sheath of Schwann** increase in size, and, it is said, also in number.

Most likely *pari passu* with these evidences of decay in the enveloping sheaths of the axis-cylinder, the **axis-cylinder** itself begins to break up into fragments. By the end of about six weeks in the frog and toad the fibre has completely degenerated, and is transformed into a mere nucleated band.

Sokolow (No. 4, i. 1874, p. 300) says that the **nerve terminations in muscles** also degenerate and in great part vanish.

Trophic Centres for Peripheral Nerves.—The fact of the whole nerve trunk degenerating beyond the point of section, and of the proximal part remaining unimpaired, shows that both motor and sensory fibres have their trophic centres high up. In the spinal cord the degeneration takes place in a direction according with that in which impressions are transmitted. With nerve trunks, however, the case must be different, because within the distal segment of the nerve the sensory and other centrifugal fibres degenerate as well as the motor.

The bulk of the centrifugal fibres seem to derive their trophic influence from the large multipolar cells in the anterior horn of gray matter in the cord; while the centripetal fibres also appear to have their trophic centres in the gray matter, probably in that of the posterior horn. It is questionable whether the ganglion on the posterior root plays the part of a trophic centre for any of the centripetal fibres. The fact which favours the view that it does not is that, so far as known, descending degeneration does not follow in the nerve trunk when the posterior spinal root is divided on the proximal side of the ganglion.

THE TRACTS OF FIBRES FOUND IN THE NORMAL SPINAL CORD.

961. Beginning in front there lies (see Fig. 466) a somewhat triangular tract of fibres immediately adjacent to the anterior fissure. It is known as the **direct pyramidal tract** or **column of Türck** (D.P.T.). Outside this is a part of the anterior column whose fibres probably are commissural between different levels of the cord. It is named the **anterior mixed zone.** Passing through it are the anterior roots of the spinal nerves; hence to the particular region from which they issue the term **anterior root zone** is sometimes applied. Bounding it superficially is a narrow strip of white matter called the **antero-lateral tract** of Gowers. This was supposed formerly to be simply part of the direct cerebellar tract, but this view has lately been disproved. Occupying the greatest area in the lateral column, lying somewhat deeply, and abutting upon the posterior horn, is a wedge-shaped tract of great size and of primary importance—the **crossed pyramidal tract**—so called because the motor fibres which have decussated in the anterior pyramids are concentrated within it. Occupying the circumference of the cord back to the posterior nerve root is the **direct cerebellar tract.** Immediately behind this, and still lying at the circumference of the cord, comes next a column of fibres known as **Lissauer's tract.** It is separated into two by the posterior nerve root.

The **posterior column** is divided by the interfunicular artery into an inner and an outer half. The inner is wedge-shaped and is known as the **postero-internal column** or **tract of Goll;** the outer goes by the name of the **postero-external column** or **tract of Burdach.** In the medulla oblongata these become respectively the **funiculus gracilis** and the **funiculus cuneatus.** The former encloses a mass of nerve cells known as the **clavate nucleus,** the latter a similar mass called the **triangular nucleus.**

A good many of the fibres of the posterior nerve root pass inwards at the posterior and outer angle of the column of Burdach. This area is named, accordingly, the **posterior root zone.**

Lying in the bay constituted by the junction of the two horns of gray matter, and immediately adjacent to the gray matter, is a thin band of white substance—the **lateral boundary zone.**

Descending Secondary Degenerations following Lesions of the Brain.

Trophic Centres for descending Fibres.

962. Türck regarded the *basal ganglia* as the trophic centres for the fibres descending from the brain to the cord. He found that, when these were destroyed, a descending degeneration followed within the pyramidal tracts below. This view is not entertained at the present day. We know now that the trophic centres for the pyramidal tracts are located in the *motor cerebral cortex*, not in the corpus striatum, as Türck supposed. The cause of the descending degeneration in destructive lesions of the basal ganglia is that the fibres of the inner capsule coming from the cortex are usually torn across. As in the cord so in the brain, the distal part degenerates no matter where the continuity of the fibre is interrupted.

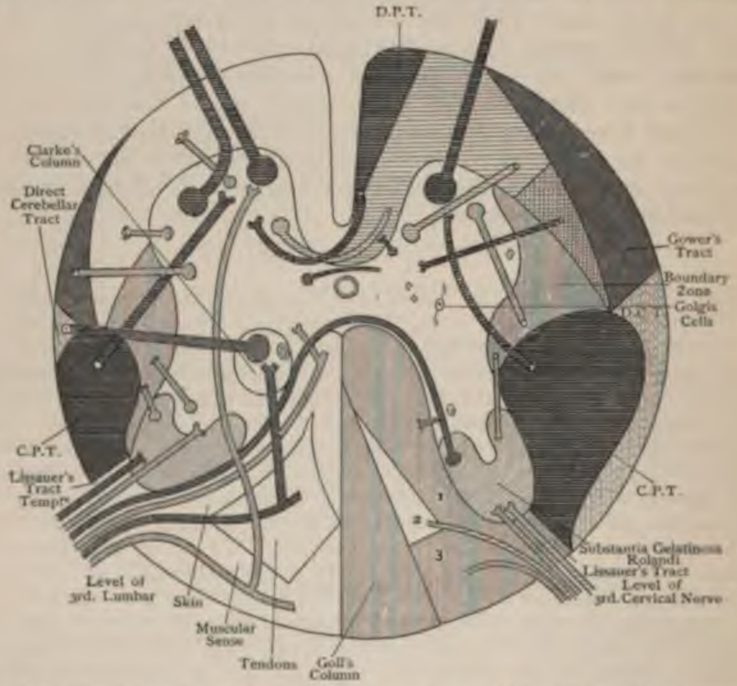


Fig. 466.—Representation of Tracts of the Spinal Cord. (After Flechsig. From a drawing lent the author by Dr. Bulloch, and reproduced with Prof. Flechsig's kind permission.)

General Course followed by the Degenerating Fibres.

The fibres which in Man degenerate in a direction downwards are derived in great part from the so-called *motor area* of the cerebral cortex. Immediately beneath the point of injury to the cortex, and while as yet within the centrum ovale, the degeneration is somewhat diffuse, but when the inner capsule is reached the degenerated tract becomes limited chiefly to the *knee and anterior two-thirds of the posterior limb of the inner capsule*. It is next found in the *crusta* or superficial layer of the cerebral peduncle. Then entering the *pons* its fibres break up into bundles, to become again concentrated in the *anterior pyramid* of the same side. About three-fourths of them cross in the pyramids to run down the *opposite lateral column* of the cord in what is known as the *crossed pyramidal tract*. The remainder pass into the *crossed and direct pyramidal tracts on the same side of the cord.*

Bilateral Degeneration.—Up to a given time the degenerative changes in the cord are confined to the crossed pyramidal tract of the side opposite to the cerebral lesion. In due course, however, the degeneration begins to show itself in the crossed pyramidal tract of the same side. The new tract is so evident as to be traceable with the naked eye from the third cervical root throughout the whole cervical enlargement.

This bilateral degeneration of the crossed pyramidal tract as a result of a unilateral cortical lesion has long been recognised. Charcot many years ago drew attention to it in cases of old-standing hemiplegia. Pitres (No. 4, iii. 1884, p. 142) described numerous instances of it in Man. The lesions of the brain which occasion it, he says, may be small, but always have a bearing upon the motor area of the cortex either directly or through the fibres emanating from the parts destroyed. In all cases the degenerated tract was single down as far as the pons and anterior pyramid, but was found in both crossed pyramidal tracts of the cord. In four out of ten cases the degeneration was more intense on the side opposite to the cortical lesion, but in six it was symmetrical. In four cases the direct peduncular tract (Türck's column) in the anterior column was normal, and in six it was slightly altered, but there was no constant relationship between this and the degeneration in the lateral tracts. In the four cases where the degeneration in the lateral columns was unequal on the two sides the columns of Türck were twice normal, once they were degenerated on both sides but unequally, while in the remaining instance the column was sound on one side and degenerated on the other.

Hadden and Sherrington (No. 521, viii. 1886, p. 502) found this bilateral degeneration as the result of an old hæmorrhage into the inner capsule.

Moelli (No. 517, xiv. 1883, p. 173) produced it experimentally in dogs as a result of unilateral excision of parts of the cerebral cortex. The opposite pyramid, he emphasises, was never affected. Muratoff (No. 51, 1893, Anat. Ab., p. 97) confirmed these observations. Schäfer (No. 179, iv. 1883, p. 316) noticed it in the monkey; and Boyce (No. 6, 1893, ii. p. 688) in the cat.

Cause of Bilateral Degeneration.—This is somewhat obscure. Charcot (No. 524, p. 252) supposed that it was the result of some of the pyramidal fibres crossing in the anterior commissure, but the argument against this theory is that the anterior commissure is always found to be sound.

Sherrington (No. 179, x. 1879, p. 431) believes that the fibres of the crossed pyramidal tract cross the middle line twice, firstly in the pyramids, and, secondly, lower down. On that account he calls it "the recrossed tract."

According to Pitres there is evidence to show that while in hemiplegia with descending degeneration the side of the body opposite to the cerebral lesion is paralysed, that on the same side is distinctly paretic, thus pointing, he thinks, to the above tract being cortical in its origin. It is an interesting anomaly, however, if this be so, that it does not diminish steadily downwards, but is more voluminous in the lower dorsal and lumbar regions than in the mid-dorsal. He says that in Man it is usually first noticed between the third and seventh cervical nerve roots.

Curiously, the part of the cortex whence this degeneration most readily proceeds is, in the case of the monkey, at the lower end of the Rolandic fissure, a region which has been shown by Semon and Horsley to elicit bilateral contraction of the laryngeal muscles.

Langley in supplementing Sherrington's explanation supposes that the tract in question may be accounted for by the motor cells in the anterior cornu on the side opposite to the lesion degenerating. From these cells, there is reason to believe, fibres arise which cross in the commissure, and some of them, he alleges, pass into the crossed pyramidal tract. The above nerve cells in old hemiplegias no doubt sometimes degenerate, but it is difficult to get over the fact that the anterior commissure remains uninjured. Ziehen (No. 175, xviii. 1887, p. 302), while denying that there is any direct connection of the cerebral cortex with the crossed pyramidal tract of the same side, supports Langley's view that there may be this indirect communication through the intermediation of nerve cells.

These theories have all been disproved by the more recent observations of Muratoff (No. 51, 1893, Anat. Ab., p. 97), Boyce (No. 6, 1893, ii. p. 688), and Mellus,[1] made on the medulla oblongata and cord stained by Marchi's method (No. 621, 1887, p. 208).[2]

From these researches it is placed beyond doubt that the fibres of each pyramid split into two sets. One of these, the larger of the two, goes to the lateral tract of the opposite side, another to the corresponding tract on the same side.

---

[1] Not yet published; to appear in *Proc. Roy. Soc.* 1894.

[2] This method is as follows:—A small brain or the cord is hardened in Müller's fluid for a week, or, it may be, is plunged into hot Müller (Mott). In the case of the human brain, inject with Müller's fluid as described in vol. i. p. 56. Then cut into slices not thicker than 0·5 ctm., and place in a mixture of 2 parts Müller's fluid and 1 part of a 1 per cent solution of osmic acid. Wash thoroughly and embed in celloidin. Clarify and mount in Canada balsam. The degenerated fibres stain black, and do not lose this on being clarified, while the surrounding parts have only a dull grayish-brown tint. The method may be combined with Pal's stain. Schäfer recommends the following adaptation:—Harden for a month in Müller's fluid, cut sections, and then put into the above Marchi's mixture of Müller's fluid and osmic acid for twenty-four hours. Stain overnight in the following:—

Hæmatoxylene 1 grain (dissolved in a little absolute alcohol).
Acetic acid 2 c.c.
Distilled water 100 c.c.

The sections become black. Bleach by Pal's method (see vol. i. p. 82), allowing the sections to remain for as much as ten minutes in the permanganate of potash solution, and then continue the bleaching in the oxalic acid and sulphite of potassium mixture.

Periods at which the Degeneration occurs in the Cord.

It should be mentioned that the degeneration in the lateral column of the same side differs from that in the contra-lateral in being accompanied by far less overgrowth of connective tissue. In the *fourth month* the increase of the connective tissue elements in the opposite lateral column is very obvious; fine blood-vessels are abnormally abundant and the degenerated tracts are paler and more distinctly defined than before. If the cerebral lesion has been large the pyramid of the same side as the lesion is recognisably smaller than that on the opposite.

When the *fifth month* has been reached the degeneration of the lateral column on the same side as the cerebral injury runs (in the dog) throughout the cord from the posterior end of the decussation of the pyramids to the second lumbar nerve root.

Eleven months after the infliction of the cerebral injury the pyramid corresponding to the injured hemisphere is still more shrunken than before, and it is with great difficulty that any degeneration in the lateral column on the same side can be shown.

Localisation of particular Fibres in the Descending Tracts.

In the Inner Capsule.—On the accompanying scheme (Fig. 467) are marked the various excitable motor regions in the inner capsule of the monkey, according to Beevor and Horsley. As will be noticed, they occupy the knee and anterior two-thirds of its substance. It is in these parts also that the descending secondary degenerations are found.

In the Substantia Nigra.—The substantia nigra does not generally suffer from the effects of cortical lesions. In the case recorded by Bechterew (No. 517, xix. 1887, p. 13), and previously referred to (p. 677), however, it was markedly degenerated and shrunken as a result of cortical lesion combined with destruction of parts of the basal ganglia. Bechterew looks upon the injury to the ganglia as accounting for it, holding as he does the ganglion to be connected with the corpus striatum. Witkowski has also described implication of the substantia nigra in descending degeneration.

In the Pedunculus Cerebri.—The idea for long entertained on the localisation of the tracts in the pes pedunculi was that fibres run in the lateral segment (third), that segment known as Türck's bundle, which subserve purposes of sensation. Flechsig refuted this view, seeing he made out that the fibres of the part of the pes in question arose from the cell elements of the pons. It was also formerly maintained that the descending motor fibres are contained in the middle third, while the function of those within the inner third was thought to be uncertain. These views have of late undergone considerable modification.

Bechterew, in the above case, describes very carefully the secondary degenerations, where destructive injury annihilated or separated from subjacent parts the following convolutions on the left side, namely: *the greater extent of the frontal, both central, all the parietal and temporal convolutions, together with the island of Reil,* also the *major part of the occipital lobes*—that is to say, where the cortex of *nearly the entire left cerebral hemisphere* was isolated from its connections below. In addition to this, the outer and inner capsules were totally rooted out, as well as the lenticular and caudate nuclei, and the lateral portion of the thalamus.

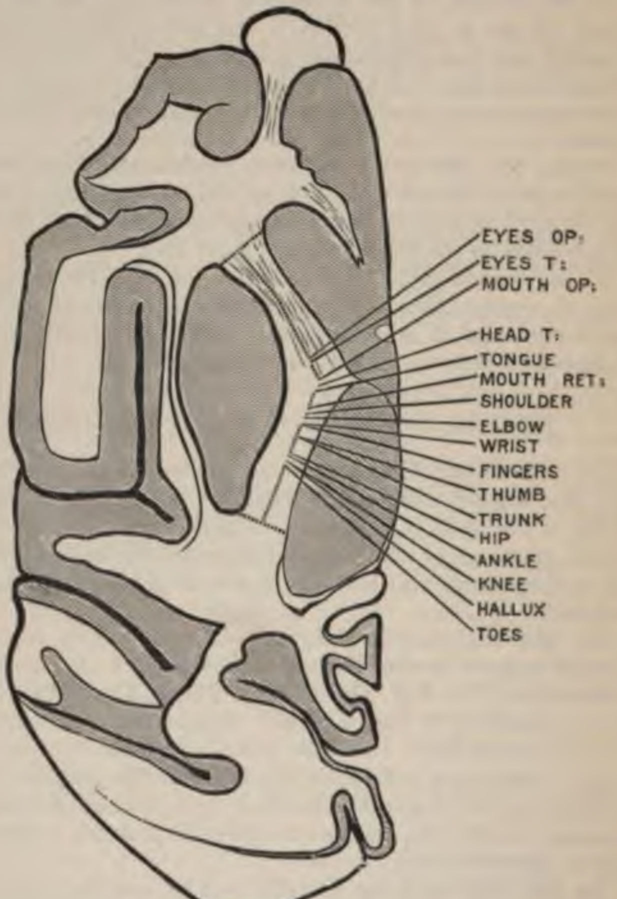


FIG. 467.—ARRANGEMENT OF THE MOTOR FIBRES IN THE INNER CAPSULE, ACCORDING TO BEEVOR AND HORSLEY.

The secondary degeneration of the pes pedunculi was on the *same* side, and spread throughout all its parts. The entire pes was shrunken so that it appeared to be only a third the size of that on the opposite side. *All three segments,* the inner, middle, and outer, were involved, and there was also undoubted atrophy of the substantia nigra.

As regards other parts, the *pons* was much flattened on this side, and all its longitudinal fibres appeared to have degenerated. Not only the fibres but the nerve cells seem to have suffered, more particularly at the upper and inner levels. The transverse fibres of the pons had not deteriorated, and the middle cerebellar peduncle showed no difference on either side.

Below this the degeneration was confined entirely to the *left pyramid*, which was only half as large as the right.

In the spinal cord the degeneration occupied the *crossed pyramidal tract of the contra-lateral column;* while there was not a trace of degeneration in the anterior columns.

This, he states, is the only case on record where the entire pes degenerated as a result of a cortical brain lesion.

From careful study of the effects of different cortical lesions Zacher (No. 517, xxii. 1891, p. 654) differentiates the tracts in the pedunculus in the following manner :—

Suppose, to begin with, that the peduncle is divided longwise into four nearly equal parts, then the fibres which run in the *outer fourth,* he finds, come from the *occipital* and *temporo-sphenoidal* lobes, and reaching the upper levels of the *pons,* terminate here.

The *second outermost fourth* of the peduncle is in great part occupied by the *pyramidal tract,* an allegation which is supported by Flechsig's observations. In destructive injuries of the motor part of the inner capsule fibres must be severed which have nothing to do with the pyramidal tract. These, according to Zacher, end in the pons. They also run in the second outermost fourth of the crus, and although, as just said, not pyramidal, are often included under this designation.

The fibres of the *third fourth* of the pes measuring from the outer border arise most likely in chief part from the *corpus striatum,* and probably also from the *ascending frontal convolution.*

Flechsig supposed that the *median (inner) fourth* received its fibres from the frontal lobe. With this Zacher cannot agree. He endeavours to prove, on the contrary, that the fibres running in this innermost or mesial fourth of the pes are derived from the neighbourhood of the *island of Reil* and base of the *lenticular nucleus,* and find their peripheral attachment in the upper levels of the pons.

In the Cord.—An interesting question comes to be whether particular areas in the descending tracts correspond to specific regions of the cerebral cortex. The general impression (Löwenthal, Sherrington, and others) seems to be that although the absolute number of the degenerated fibres in the case of the crossed pyramidal tract may vary, yet that the extent of surface covered by them is alike, whatever the position of the cortical defect. There must be an intermingling therefore of the fibres of the tract in their course downwards.

The degeneration of the crossed pyramidal tract after removal of the "cord area"[1] of the cortex does not, according to Sherrington, correspond exactly with Flechsig's "pyramidal tract." The latter, he says, is greater in extent. Löwenthal (No. 169, xxxi. 1883, p. 350) remarks that the secondary degeneration of the lateral column following cross section of the cord is much larger than that propagated from a brain injury, thus showing that in all probability a considerable number of the crossed tract fibres are derived from the cord itself.

---

[1] See p. 642.

Ziehen (No. 517, xviii. 1887, p. 300) has had the opportunity of examining the parts in several dogs where during life specific portions of the cortex had been excised.

In a case where the cortical area for the anterior limb on the left side had been removed two and a half months previously by Munk, he found that the degeneration in the cord was entirely confined to the right lateral column, and to that part of it lying closest to the gray matter. The degeneration, however, was not absolute. Undegenerated fibres were mixed up with the degenerated, and some degenerated fibres were scattered through other parts of the tract. High up in the cord the degenerated fibres occupied the spaces found normally within the meshwork at the side of the gray matter. It was only in the most anterior of these spaces that he could discover normal nerve fibres.

Above the crossing of the pyramids the chief part of the fibres were aggregated in the dorsal and lateral parts of the pyramids, and in the pons they constructed a tract quite as compact as that within the cord.

It has previously been remarked that in the dog the direct pyramidal tract is probably absent. In Man, as the result of a brain lesion, it degenerates very irregularly, in some cases being implicated, in others no degeneration being perceptible. Pitres (No. 4, iii. 1884, p. 142) explains these anomalies by the irregularity in the distribution of the pyramidal fibres. Out of forty cases of secondary degeneration of the cord from unilateral brain lesion, he found the direct tract degenerated in six, but the extent of the degeneration was uncertain and always slight. In one case only did he find it in the lower dorsal and lumbar regions. In three cases there was degeneration of both direct tracts.

Both Sherrington and Singer are at one in denying the existence of the direct pyramidal tract in the cord of the dog, and there seems no reason for thinking that the degenerated fibres in the lateral tracts on the same side as the brain lesion are in any way representative in the dog of the direct pyramidal tract of Man.

So far as the facts admit of generalisation it seems allowable to conclude :—

(1) That the tracts which are contained in the crusta are all descending.

(2) That the function of a large proportion of them is motor, but that this does not hold good of the whole of them.

(3) That none of them are sensory.

(4) That the outer fourth contains fibres from the occipito-temporal region; that the fourth next to this carries the fibres of the peduncular tract; that the fibres in the third fourth measuring from the outer border arise most likely from the caudate nucleus and ascending frontal convolution; and that the origin of the fibres in the inner (mesial) fourth, although not made out with exactitude, seems to be from the basal ganglia and neighbourhood of the island of Reil.

Distance to which the Descending Tracts extend.

The general supposition is that the fibres of the descending tracts are not in direct communication with the muscles, but that the nerve cells of the anterior horn are interposed. There is difficulty, however, in making out the actual connection between the descending lateral tract and the motor cells of the cord. The tract, one would think, and more especially is this true of the lower reaches of the cord, retreats as far as possible from their neighbourhood. Moreover, although the nerve cells of the anterior horn are sometimes found degenerated in old hemiplegics, the anterior nerve roots never are, so long as the nerve cells of the anterior horn are intact.

In Man the **crossed pyramidal tract** is usually said to end opposite the **second lumbar nerve root.** Tooth (No. 6, 1889, i. p. 826) has traced it as far as the **fourth lumbar,** and even lower.

Bouchard stated that the **direct pyramidal tract** did not extend downwards farther than the **mid-dorsal region.** Tooth, however (*loc. cit.*), has found its fibres degenerated at the **eleventh dorsal,** and even, in one case, at the second lumbar, as the result of an inner capsule lesion.

Lesions of the Brain which give rise to Descending Degeneration.

The ultimate cause of descending degeneration from a lesion of the cerebral cortex is of course the separation of the fibre from its trophic nerve cell. The causes of this separation are usually **embolic or porencephalous softening, hæmorrhage into the basal ganglia and inner capsule, tumours of the pons and of the spinal cord,** or, it may be, **fracture and dislocation of one or more vertebræ.** Schultze states that he found the crossed pyramidal tracts absent in a case of hydrocephalus, but suggests that they may have been congenitally wanting.

SECONDARY DEGENERATIONS FOLLOWING DESTRUCTIVE LESIONS OF THE CORD.

It has now been ascertained that the part of the fibre which is separated from its nerve cell degenerates simultaneously throughout its course. The terms "ascending" and "descending" degeneration nevertheless are in common use when speaking of the tracts of degeneration in the cord. They refer, however, to the centripetal or centrifugal function normally possessed by the tracts rather than to the actual course followed by the degeneration. The part of the divided nerve fibre which degenerates is in accordance with the direction in which the fibre transmits impressions. Thus if the cord be divided transversely certain tracts degenerate above, certain below the point of section. Those above are known as the "ascending," those below as the "descending" tracts.

The Descending Degenerations.

963. The tracts which we have found degenerating downwards as a result of cortical lesion are the *crossed* and occasionally the *direct* *pyramidal*. As may be imagined, the degeneration within these proceeds to its full extent when the result of transverse section of the cord, and in addition to these, considerable degeneration is usually noticed in the *anterior mixed zone* (Fig. 466). This zone is supposed to consist, in part at least, of fibres which are commissural between different segments of the cord, and which consequently degenerate when divided.

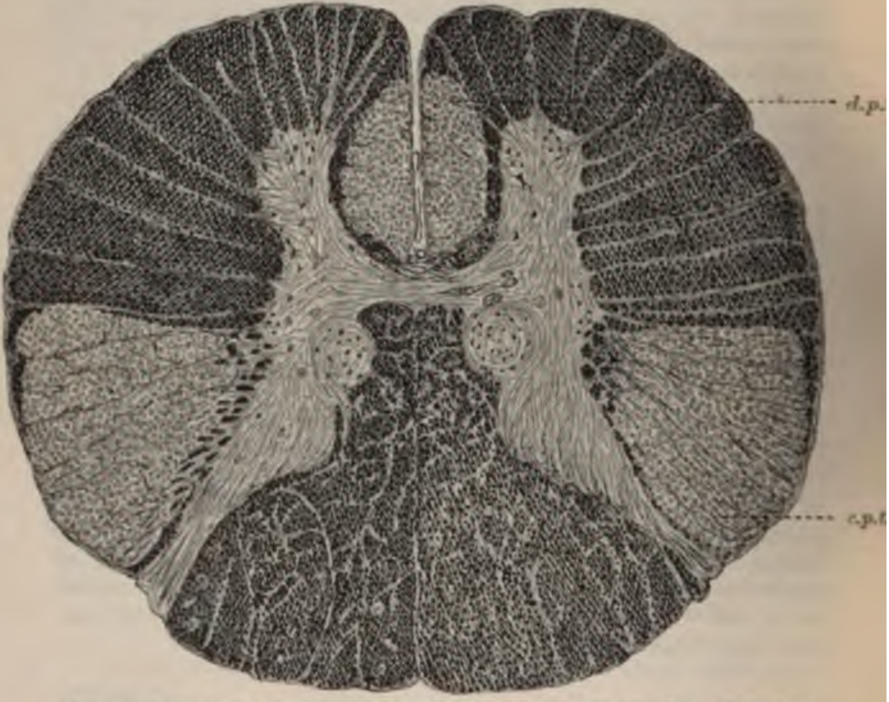


FIG. 468.—DESCENDING DEGENERATION OF THE CORD RESULTING FROM ITS COMPRESSION AND ALMOST COMPLETE SEVERANCE. UPPER DORSAL REGION (×50 DIAMS., reduced).

(*d.p.t.*) Degeneration in the direct pyramidal tract; (*c.p.t.*) degeneration in the crossed pyramidal tract (Picro-carmine and Farrants' Solution).

Another descending tract of degeneration of less constant occurrence lies in the postero-lateral column, and is known as the *comma-shaped tract* from the character of the outline presented by it when cut across. Its position in the postero-lateral column is such that it divides the column equally. It is most often seen when the cord is divided above the fifth dorsal root.

The shape of the crossed pyramidal tract of degeneration in Man is more or less triangular. In the dog and monkey it inclines to the circular. In the cervical and upper half of the dorsal regions it is prevented from coming to the surface by the narrow superficial slip of white matter known as the direct cerebellar tract. Below this, however, it approaches more and more towards the surface. It gets smaller in its progress downwards, and hence must give off fibres progressively. It is largest opposite the second dorsal nerve.

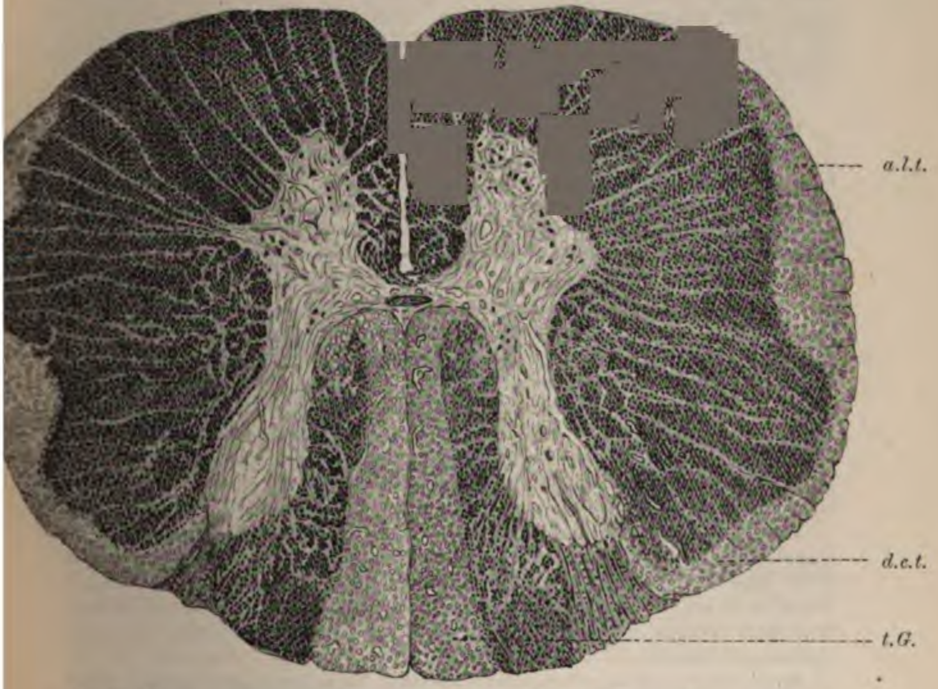


FIG. 469.—ASCENDING SECONDARY DEGENERATION OF THE CORD IN CERVICAL REGION RESULTING FROM ITS COMPRESSION AND ALMOST COMPLETE SEVERANCE IN UPPER DORSAL REGION (×50 DIAMS., reduced).

(*a.l.t.*) Antero-lateral tract; (*d.c.t.*) direct cerebellar tract; (*t.G.*) tract of Goll (Picro-carmine and Farrants' Solution).

The Ascending Degenerations.

964. These are best studied when the cord is divided experimentally in animals or by accident in Man. A good deal depends

upon the part cut across, but if the mid-dorsal region be the seat of it the following are found to be the tracts which suffer: (1) the postero-external columns; (2) the postero-internal columns; (3) the direct cerebellar tracts; (4) frequently the small wedge-shaped tract described by Gowers, and named the "antero-lateral tract."

It must not be supposed that the ascending tracts are all necessarily sensory. Although the course of the fibres which are bearers of impressions to arouse consciousness is not as yet clearly known, still it seems to be generally admitted that those at least which excite a *sense of pain* pass upwards in the *gray matter of the cord on the opposite side.* The antero-lateral tract above referred to has been asserted to be a path for painful impressions (Gowers), but not with proof sufficiently striking to bear out the assertion.

In the case of the dog the following was found by Singer (No. 12, lxxxiii. H. 1, Ab. III. 1881, p. 394) to be the localisation and course of the ascending tracts. The true "secondary degeneration" occupied two positions, namely, the posterior columns and the direct cerebellar tract. Near the point of section the entire posterior columns were the seat of degenerated fibres, while the direct cerebellar tract had already become sharply demarcated from surrounding parts.

At the distance of a nerve interspace above this the destruction of nerve fibres in the posterior columns began to be less general. In the portions of the columns of Burdach adjacent to the posterior horns a few normal fibres now made their appearance, and in the fibres of the posterior commissure, which heretofore were degenerated, healthy nerve fibres were noticed. Higher up, the degeneration of the posterior columns began to retreat more and more into Goll's tracts, and ultimately became entirely confined to them (see p. 733). It did not, however, occupy the whole of these columns, but was confined to two triangular areas at their most posterior and mesial parts. It was further traced upwards through the medulla oblongata to the nucleus of the funiculus gracilis.

The other tract of degeneration (direct cerebellar) lay quite superficially in the lateral column. It extended from the caput cornu posterioris, and ran alongside of it for some distance forwards to the attachment of the ligamentum denticulatum —that is to say, to nearly midway in the periphery of the antero-lateral column. This tract commences below, in Man, about the level of the ninth dorsal nerve (Kahler and Pick, No. 517, x. 1880, p. 196).

In the dog it is by no means sharply cut off. Normal fibres were present within it, and anteriorly its degenerated fibres mingled diffusely with those of the anterior column. In the cervical region the tract became more condensed and mostly limited to the posterior part of the periphery of the lateral column. It can be traced up to the corpora restiformia, but not further, as the bundles become separated by the fibræ arciformes.

So far this is practically identical with what occurs in Man, but, as just remarked, there is also found in many cases a small tract of degeneration known as the "antero-lateral." It lies at the anterior extremity of the direct cerebellar tract, and is sometimes regarded as a part of it. It runs up to the medulla oblongata, but whether it ends here or not is doubtful.

Trophic Centres for the Ascending Fibres.

965. It seems to be a conclusion which is inevitable that those fibres of the **posterior columns** which degenerate up to the medulla oblongata have their trophic centres in the *posterior nerve ganglion.* There may, however, be others (commissural) within these columns which have their trophic connections in the *gray matter of the cord* itself.

The **direct cerebellar tract,** in the dorsal region at least, is generally admitted to be trophically united with the cells of Clarke's posterior *vesicular column.* Tooth (see p. 732) holds, however, to many of the fibres in the cervical region being derived from the posterior nerve roots, and hence we may suppose their trophic nerve cells to reside in the ganglia.

It is difficult to say where the **antero-lateral tract** receives its trophic influence from. Two things seem to be pretty certain, however, namely, that its fibres arise lower down than those of the direct cerebellar tract, and that they have not any connection with the posterior nerve roots. The tract does not degenerate when the posterior nerve roots are divided (Tooth).

Destination of the Ascending Tracts.

966. The **direct cerebellar tract** runs into the restiform body and is alleged to terminate in the cerebellum.

Tooth has traced the **antero-lateral tract** in the monkey as far as the points of exit of the sixth and seventh cranial nerves, but nothing is known definitely of its further course. Presumably it ends in the nucleus lateralis.

The tracts in the **postero-internal** and **postero-external columns** are generally said to terminate in the funiculi gracilis and cuneatus. It is questionable, however, whether in all cases this is strictly accurate. There are instances on record in which the ascending secondary degeneration could be traced from these two funiculi upwards through the crossing of the fillet into the regio subthalamica. There is good reason for believing that this is possible, for through the researches of Spitzka, the experiments of v. Monakow, and the embryological observations of Flechsig and Edinger, it has been pretty well established that the fillet is a crossed process of the posterior columns. Fibres are apparently given off from the funiculi gracilis and cuneati, which arch round as fibræ arcuatæ internæ, pass into the formatio reticularis, cross the middle line in front of the central canal, and so come to construct the fillet of the opposite side.

Lastly, seeing that the path for impressions which excite painful sensibility seems to traverse the opposite half of gray matter, it may be asked whether there is anything to indicate that an ascending tract of degeneration is found in it when the continuity of the column of gray matter is interrupted. Direct observations on this subject are scanty, and not always reliable. It may be mentioned, however, that Rosolimo (No. 517, xxi. 1890, p. 897) has recorded a case bearing upon it. The case was one in which a gliomatous tumour mass, situated entirely within the posterior horn of gray matter and extending throughout the upper dorsal and the entire cervical regions, induced secondary degeneration in the opposite interolivary layer and lemniscus (fillet).

Structural Alterations of the Degenerated Tracts.

967. Macroscopically, the degenerated tracts at first show more opaquely white than their surroundings, and when the cord is hardened in a chrome salt they assume a bright yellow colour. In the course of from three to four months, however, the tracts lose their opaque white appearance and assume a gray gelatinous aspect.

If the degeneration has been experimentally or accidentally evoked, by cross section of the cord there is noticed for about a centimètre above and below the point of section what Schiefferdecker (No. 13, lxvii. 1876, p. 557) has named the **traumatic degeneration.**[1] In most instances this appears to be of inflammatory origin, and is characterised by swelling of the axis-cylinders, congestion of the vessels, and crowding of the parts with a small-cell deposit. Schiefferdecker alleges that the posterior columns escape this degeneration, and Singer (No. 12, lxxxiii. H. 1, Ab. III. 1881, p. 394) agrees with him.

It is in the parts above and below the areas of traumatic degeneration that the tracts of true secondary degeneration are seen. Schiefferdecker (No. 13, lxvii. 1876, p. 570) was of opinion that the fibre degenerated progressively from the nerve cell outwards, while Bouchard (No. 107, 1866, p. 272) held that the degeneration took place simultaneously throughout its extent. The latter view is probably the correct one. Within the same tract, however, some fibres take longer to degenerate than others. In a young growing animal the degeneration apparently spreads quicker than in one which has reached maturity.

There is, or rather was, a difference of opinion as to what part of the nerve tube the degeneration commenced in. It is now admitted pretty generally that, as in peripheral nerves, the medullary sheath and axis-cylinder are affected almost simultaneously. Homén (No. 40, xcvi. 1883, p. 1681) indeed states that in dogs the degeneration originates in the axis-cylinder, soon affects the medulla, and lastly spreads to the neuroglia. According to Tooth (No. 6, 1889, i. p. 754), swellings occur upon the axis-cylinder within the first two weeks something similar to those seen in myelitis; and by the end of this time the myeline has broken up. By the end of the fourth week the remains of the axis-cylinders have vanished and the fibres of the tract appear universally degenerated.

---

[1] It is important in studying these secondary degenerations to apply as exhaustive a technique to their elucidation as possible. More particularly is it essential to examine unclarified as well as clarified preparations. The method of clarification, although extremely useful for localising the position of the tracts, does not of itself afford a complete picture of what has taken place within them.

While this is going on (twenty-nine days, Homén) numerous *compound granular corpuscles* show themselves in the degenerated areas, so numerous that, as Bastian (No. 34, 1867) long ago pointed out, they form an excellent guide to the position of the affected tracts. They are also met with in other brain degenerations such as the softening resulting from embolism, tumours, etc. Virchow (No. 13, x. 1856, p. 407) held the view that the glia cells were their chief source. In secondary degeneration, however, this cannot be so, because the neuroglia does not perish but, on the contrary, proliferates. A much more likely origin is from the swollen axis-cylinders and the remains of the myeline surrounding them, a supposition which is borne out by the fact that the granular bodies in question are found occupying the site of the axis-cylinders.

In about *three weeks* after the severance of the fibre from its trophic cells *the glia shows evidence of proliferation.* Its cells become much more numerous, especially along the adventitia of the vessels. They are mostly unbranched, and may in part be derived from the pre-existing glia, in part may be blood-leucocytes. Charcot took the view (No. 524, p. 160) that the interchange in the glia was alike with that of locomotor ataxia and of multiple sclerosis. Bouchard and others (No. 107, 1866, p. 272) recognise in the sclerosis of locomotor ataxia a primary affection which progressively invades the nerve tubes and causes destruction of them. Their medullary sheath becomes denuded and leaves the cylinder-axis bare. In secondary degeneration, on the other hand, as already described, the cylinder-axis is always destroyed and never exposed.

True *corpora amylacea* are much rarer in secondary degeneration than in the sclerosis of locomotor ataxia. If colloid bodies are found, they are as a rule derivatives of the axis-cylinders.

Langley and Sherrington have noticed what is probably an inflammatory affection—what they call a chronic myelitis without the sclerosis—late in the degeneration. Langley proposes to call it "tertiary degeneration."

Progressive Alteration of Parts. — The shortest period observed by Singer (No. 12, lxxxiii. H. 1, Ab. III. 1881, p. 402) in which a tract degenerated completely in the adult dog was twelve days. By this time the degeneration had reached the medulla oblongata. He states, however, that the degeneration is most evident by the fifth week. In the young dog, on the other hand, he has found the ascending tracts completely degenerated by the end of one week, and well-marked signs of shrinking had shown themselves by the fourth to the fifth week. Homén (No. 534) states that on microscopic examination he was able to detect commencing degeneration in the posterior columns of the cord three days after hemisection.

The degeneration begins in some tracts earlier than in others. Thus in Homén's hemisection experiments, although the degeneration could be detected microscopically in the posterior columns after five days, it could not be recognised distinctly in the lateral columns; while it took seven days to show itself in the direct cerebellar tract. Volkmann (No. 140, xlii. 1888, p. 450) reports that, after compression of the cord for three weeks by a gliomatous tumour, the degeneration was far more distinct in Goll's tract than in any other. Homén (No. 13, lxxxviii. 1882, p. 61) found degeneration of the human cord evident three weeks after a brain lesion.

Sherrington (No. 179, vi. p. 178) found that after destruction of portions of what he calls the "cord area" of the cerebrum of dogs, or that part of the cortex whose removal is attended by descending degeneration in the spinal cord, the appearances were as follows:—

At the end of the first *sixty hours* nothing of particular note is observable, but by the ninth day some of the axis-cylinders in the crossed pyramidal tract of the cord stain less deeply with carmine, and are rather coarsely granular instead of being homogeneous as in health.

By the *third week* the parts are in much the same state, only the altered nerve fibres are more numerous. The connective tissue framework in which the fibres are set seems also to be somewhat disarranged.

After nearly *two months* the disarrangement of the connective tissue is very apparent. Some nerve fibres have disappeared, and the cells in the neuroglia are numerous.

SECONDARY DEGENERATIONS FOLLOWING DIVISION OF THE POSTERIOR NERVE ROOTS.

Course of the Fibres of the Posterior Nerve Root.

968. The course and connections of the fibres composing the posterior nerve root are matters difficult to determine. Of late, however, by means of improved methods of staining nerve fibres, a more precise notion of where they go to on entering the spinal medulla has been obtained. It is now generally admitted that Lissauer's assertion (No. 517, xvii. 1886, p. 377) as to there being two kinds of fibres, large and small, is correct. The small lie to the outer side and become medullated later than the large. For whereas the large begin to show medullation in human embryos from 28 to 32 ctm. long, the commencement of the medullation of the small is delayed until the fœtus is 45 ctm. in length (Lenhossék, No. 14, xxxiv. 1889, p. 164).

Lenhossék divides the entire root into three categories of fibres, a **mesial**, **middle**, and **lateral**. The last of these contains the above fine fibres referred to by Lissauer.

Its elements arrange themselves first in a longitudinal bundle, which occupies a position between the gelatinous substance of Rolando and the periphery, and after a time penetrates into the posterior horn of gray matter. The fibres of the middle group penetrate through the gelatinous substance of Rolando, and entering the gray matter of the posterior horn, assume a vertical direction. Those of the mesial group split into two minor bundles, one of them entering Burdach's column, the other passing through the gelatinous substance and making its way into the gray posterior horn, and thence in a horizontal direction passing forwards to the anterior horn. The connection of the posterior root with the anterior horn he holds to be a fact thoroughly established, a connection, it will be borne in mind, which was first described by Lockhart Clarke.

Further Course in the Cord.—Of the three groups of fibres the mesial is always the largest, and constitutes the main part of the posterior root. In Man the middle group is usually small. He holds that the entire column of Burdach is composed of fibres derived from the posterior roots, and he subdivides it into three zones, a large middle, an anterior, and a posterior. The middle corresponds to what is usually designated the "posterior root zone," the others lie anterior and posterior to this. Into the middle, those fibres of the posterior root ultimately divulge, which immediately on entering the cord penetrate the posterior horn of gray matter—that is to say, the middle group. In the anterior and posterior zones stretch fibres which run through a considerable distance in a longitudinal direction.

In the lumbar region the bulk of the fibres of the mesial group of nerve roots penetrates the gray horn and passes forwards to become connected with the cells in the anterior horn, while in the dorsal part of the cord, in the portion corresponding with Clarke's vesicular columns, the connection with the anterior horn becomes less evident, and they almost all terminate in the cells of the above columns.

There is this, however, to be borne in mind, that a direct connection of these fibres with the cells of Clarke's columns is never met with, but that, so far as can be made out, the fibres simply enter the plexus surrounding the group of cells.

It is often said that the posterior root takes part in the formation of the anterior commissure. Lenhossék has never been able to persuade himself of this. The appearances are deceptive, but careful investigation proves, he says, that the anterior commissure has no such connection with the posterior nerve root.

In opposition to the views of Bechterew and Obersteiner, however, he recognises that the posterior commissure receives a contingent of the fibres of the posterior nerve root, and chiefly from the middle group of its fibres.

The middle group of fibres becomes medullated in the human fœtus of 36 ctm., and it is at this point in development that their course can alone be studied. The cord of the adult or even of the full-time fœtus is unsuited for the purpose. After entering the gelatinous substance of Rolando they pursue a longitudinal course and constitute what is known as "Kölliker's longitudinal bundle of the posterior horn." The fibres within this bundle run upwards and downwards, and from them branches are emitted which run into the posterior horn of gray matter. Some pass forward to the anterior horn and lose themselves here, it may be, although this is doubtful, by joining the nerve cells in this neighbourhood. A large proportion of these branches, however, pass into the posterior commissure, and thereby gain the opposite side of the cord. What their exact destiny is seems doubtful. The posterior commissure, he holds, is not entirely made up of these, but contains also some fibres which are commissural between the two posterior horns.

The termination of the third or lateral group, the fibres of fine calibre, is not well defined.

Lissauer's Border Zone.—Between the extreme margin of the gelatinous substance of the posterior horn and the periphery of the cord there lies a tract of nerve fibres more especially described by Lissauer (No. 517, xvii. 1886, p. 380), and named by him the "border zone" of the posterior horn. The bulk of its fibres run longitudinally, and it is easily recognised from the fineness of the fibres composing it. It is split into a mesial and a lateral segment by the entrance of the posterior nerve root, whose fibres pass in at right angles to the columns of fibres of which the "border zone" is composed. The importance of this area of white matter is that, according to Lissauer, its nerve fibres are derived from the posterior nerve root. After leaving the root they ascend in this tract and enter the so-called "spongy zone" of the substantia gelatinosa Rolando.

The Tracts of Degeneration.

969. Singer (No. 12, lxxxiii. H. 1, Ab. III. 1881, p. 403) and Tooth (No. 6, 1889, i. p. 829) have made a study of these in dogs and monkeys. The spinal canal was opened for varying distances and the posterior roots corresponding to the situation were cut across on the proximal side of the ganglion. The wound was stitched up and allowed to heal.

Singer's experiments were made on young dogs, and the time at which the animals were killed and the parts examined varied from the end of the third to the middle of the fourth week.

Four weeks after excising the posterior roots of the first and second sacral nerves, together with those of the sixth and seventh lumbar nerves on the left side, in a young dog, he found that near the point of excision the secondary degeneration was limited in the sharpest manner to the left posterior column. Up to the entrance of the sixth lumbar nerve every section showed total degeneration of this column, but at the level of entrance of the fifth lumbar nerve the degeneration began to retreat a little from the part of the column adjacent to the posterior horn of gray substance, an appearance which became more evident at the point of entrance of the fourth. When the twelfth dorsal nerve was reached the degeneration had left Burdach's column entirely and was limited almost completely to that of Goll. Such continued to be very much the disposition of parts throughout the remaining dorsal and entire cervical regions. He could trace the degenerated tract finally up to the nucleus of the funiculus gracilis, a result which he has confirmed in three other cases.

Through these observations he holds to having established a direct connection between the posterior nerve roots and the medulla oblongata.

Tooth has shown, however, that, when the divided nerve roots are high up in the cord (sixth, seventh, eighth cervical and first dorsal), in addition to the degeneration of the posterior columns, a strand of degeneration appears in the direct cerebellar tract. It lies close upon the posterior horn of gray matter. Below this level the direct cerebellar tract apparently is unaffected, and hence he argues that the direct cerebellar tract is composed of at least two sets of fibres. The fibres in the lower of these are very fine, while those in the upper are coarse. His observations would lead him to conclude that, while the latter are in all probability derived from Clarke's columns, the former are direct prolongations of the posterior nerve roots. He also holds that these fine fibres are visceral in their distribution.

The explanation of why it is that the tracts of degeneration retreat from the postero-external into the postero-internal column is to be found in the fact that the fibres entering the former occupy at first a position close by the gray matter, but, in ascending, they are supplanted and pushed mesially by similar fibres from the superjacent nerve roots. In their course upwards they are still further displaced and finally enter the postero-internal (Goll's) column. The Goll's column, as Singer has pointed out, is apparently made up of the posterior nerve roots from the sacral, lumbar, and, it may be, the lower dorsal regions. The fibres of the posterior roots of the upper part of the cord seem to run into Burdach's columns alone. The Goll's tract thus contains the fibres from the lower part of the body, Burdach's those from the upper part, and the position occupied by the different layers of fibres as they enter these columns in general terms is that those which come from the lowest regions are nearest the middle line, while those coming from regions higher up are arranged successively in layers in a direction outwards.

When the cord has been divided low down the degenerated area in Goll's tract within the cervical region is very small, and not only lies close against the posterior fissure but is confined to a triangular area near the circumference. This segment of the Goll's tract in all likelihood is lumbar, and a large proportion of its fibres are prolonged directly upwards to the medulla oblongata.

This and other centripetal tracts, however, do not seem to be constituted exclusively of fibres which ascend to the medulla oblongata. Many of them appear to be commissural for different segments of the cord.

Literature on Secondary Degenerations.—**Arloing** (Trophic Centres): Compt. rend. Soc. de Biol., iii. 1886, p. 553. **Bastian:** Med. Chir. Trans., 1867. **Bechterew** (Sec. Degen. of Cerebral Peduncle): Arch. f. Psychiat., xix. 1887, p. 1. **Bouchard:** Arch. gén. de Méd., vii. 1866, pp. 272, 441, 561; viii. 1866, p. 273. **Brink** (S. D. and Cerebral Functions): Deut. Arch. f. klin. Med., xxxviii. 1885-86, p. 285. **Brissaud** (of Cerebral Peduncle): Progrès méd., vii. 1879, pp. 777, 790. **Charcot:** Leçons sur les localisations dans les maladies du cerveau et de la moelle, Pt. ii. 1876-80; *also* (Peduncle, Pons, etc.), Progrès méd., vii. 1879, pp. 597, 757, 801. **Cossy and Dejerine:** Arch. de physiol. norm. et path., ii. 1875, p. 567. **France** (Sec. Degenerations following Lesions of Gyr. Marginalis and Gyr. Fornicatus in Monkeys): Phil. Trans., clxxx. 1890, B, p. 331. **François-Franck and Pitres** (Sec. Deg. Consecutive to Destruction of Sigmoid Gyrus in Dog): Compt. rend. soc. de biol., ii. 1881, p. 67. **Friedmann** (Degeneration Processes in Hemispherical Medulla): Neurol. Centralbl., vi. 1887, p. 97. **Hadden and Sherrington** (Bilateral S. D. of Cord from Unilateral Lesion of Cortex): Brain, viii. 1886, p. 502. **Homén:** Arch. f. path. Anat., lxxxviii. 1882, p. 61; *also*, Comptes rendus, xcvi. 1883, p. 1681; *also*, Fortschr. d. Med., iii. 1885, p. 267. **Hublé** (Cortical Motor Centres and Sec. Deg.): Arch. de Neurol., xi. 1886, p. 29. **Jelgersma** (Bilateral Sec. Deg. of Outer Bundle of Pes Pedunculi, with Atrophy of Dorsal Half of Pons and of Large Olive): Centralbl. f. Nervenheilk., ix. 1886, p. 489. **Jones** (Wallerian Method, Historical): Lancet, 1885, ii. p. 944. **Langley** (Review): Brain, ix. 1886-87, p. 92. **Löwenthal** (Difference in S. D. after Brain and Cord Lesion): Arch. f. d. ges. Physiol., xxxi. 1883, p. 350; *also*, Des dégénérations secondaires, etc., 1885. **Meyer** (in Isthmus): Gaz. méd. de Strasb., xiv. 1885, p. 109. **v. Monakow** (Cerebral Sec. Deg.): Cor.-Bl. f. schweiz. Aerzte, xvi. 1886, p. 390. **Mott** (Ascending Degenerations in Spinal Cord of Monkeys): Brain, xv. 1892, p. 215. **Pitres:** Bull. Soc. Anat. de Par., lvi. 1881, p. 628; *also*, Arch. de physiol. norm. et path., iii. 1884, p. 142; *also*, Encéphale, v. 1885, p. 79. **Schiefferdecker:** Arch. f. path. Anat., lxvii. 1876, p. 542. **Sherrington:** Journ. Physiol., vi. 1885-86, p. 177; *also* (Bilateral Degen. of Pyr. Tracts from Unilateral Cortical Lesion), Brit. Med. Journ., 1890, i. p. 14; *also* (from Cortical Lesions), Journ. of Physiology, x. 1889, p. 429; *also*, xi. 1890, p. 399. **Singer:** Sitzungsb. d. k. k. Akad., Wien, lxxxiii. H. I. Ab. III. 1881, p. 390. **Sokolow** (Degen. of N. Terminations): Arch. de physiol. norm. et path., i. 1874, p. 300. **Spitzka** (Sec. Deg. Pyr. Tract): N. Y. Med. Journ., xliii. 1886, p. 501. **Tooth** (Gulstonian Lectures): Brit. Med. Journ., 1889, i. p. 753 *et seq.* **Türck**: Sitzungsb. d. k. k. Akad., Wien, vi. 1851, p. 288; *Ibid.*, xi. 1853, p. 93; *Ibid.*, xiv. 1855, p. 329. **Volkmann** (Gliomata and Sec. Deg.): Deut. Arch. f. klin. Med., xlii. 1887-88, p. 433. **Waller** (New Method for Study of Nerv. Syst.): Lond. Journ. Med., iv. 1852, p. 609. **Walter**: Arch. f. path. Anat., xx. 1861, p. 426. **Ziehen** (Sec. Degen. after Extirpation of Cortical Motor Centres): Arch. f. Psychiat., xviii. 1887, p. 300.

THE INVOLUTION FOLLOWING REMOVAL OF PERIPHERAL PARTS.

970. It has already (p. 714) been noted that when a spinal nerve is divided it is the peripheral segment which suffers ordinary secondary degeneration. The proximal end remains for the time being intact. In course of years, however, if the continuity of the nerve is not established, a shrinking occurs in the proximal part. The gray matter with which the divided fibres were connected also undergoes a degenerative change or process of involution, presumably connected with the disuse of the nerve cells and portions of the nerve fibre still remaining.

After Amputation.—Some of the best examples of this condition are to be found after amputation of a limb. As a general statement it may be said that years after an amputation has been performed the nerve trunks in connection with the stump undergo some amount of shrinking. Both nerve roots, but especially the posterior, lose certain of their fibres. The part of the posterior column corresponding with the site of amputation is diminished in bulk, and the nerve cells both in the anterior and posterior horns of gray matter are partially destroyed. The posterior horn of gray matter also presents a somewhat shrunken aspect.

After Evulsion of Nerves.—In the same category are to be reckoned those involutions of central parts of the brain following upon evulsion of the cranial nerves and excision of certain parts of the cortex. As v. Gudden (No. 518, xxv. 1879, H. 1, p. 1) has shown, when particular nerves such as the sciatic or facial are torn out close up to their points of issue from the respective cavities which emit them, not only do any peripheral remains of the nerve degenerate, but the portion of the nerve path still within the cord or brain, together with the ganglion cells forming the nuclei of origin, also disappears. It is questionable whether in any of these cases the process of destruction of the fibre is identical with secondary or Wallerian degeneration.

After Removal of the Eyeball.—Even when peripheral organs such as the eyeball are excised, the central parts with which they are connected suffer involution. Thus v. Monakow (No. 517, xii. 1882, p. 141; *Ibid.*, xiv. 1883, p. 699) found that after removal of the eyeball in young animals the corpus geniculatum externum suffers atrophy. It would thus seem, as Forel suggests (No. 517, xviii. 1887, p. 170), that the ganglion cells of the retina emit processes which terminate in this ganglion. A similar relationship seems to exist between the retina and the occipital lobe.

THE INTRACEPHALIC INVOLUTIONS FOLLOWING REMOVAL OF PARTICULAR AREAS OF THE BRAIN.

971. A condition allied to the above-mentioned involution of ganglia from excision of peripheral organs such as the eyeball is seen when particular parts of the cerebral cortex are destroyed. One of the best examples of this is the involution of central parts which follows extirpation of the occipital lobes. v. Monakow (No. 517, xii. 1882, p. 141) describes how when a portion of the left occipital cortex in the rabbit is removed there is found, eleven months afterwards, extensive destruction of the medullary substance underlying the part, and of the posterior limb of the inner capsule on the same side, together with involution and destruction of the cells of the left external geniculate body and of the segment of the optic connected with it, of the outer stratum of the thalamus opticus, and of the anterior corpus quadrigeminum, all on the same side as that operated on.

There is some doubt as to whether a distinct line of secondary degeneration in Man can be made out within the *parieto-occipital band* (No. 521, vii. 1885, p. 89), when the occipital lobe is removed. In a case recorded by the author where one occipital lobe was entirely cut out by a tumour, some amount of degeneration could be traced forwards for a short distance. It seemed to be inflammatory rather than atrophic in its causation.

In several cases, however, where one or both occipital lobes had been destroyed the optic tracts have been described as smaller than usual.

It should also be borne in mind that there are certain cases on record showing that the occipital fibres in the parieto-occipital band suffer from secondary degeneration. Thus v. Monakow (No. 517, xvi. 1885, p. 317) describes a case where an old hæmorrhagic cyst was located in the midst of the parieto-occipital band towards its posterior extremity, and where a tract of degeneration could be traced forwards from the injured spot into the pulvinar, the corpus geniculatum externum, and the anterior corpus quadrigeminum. Zacher (No. 517, xxii. 1891, p. 654) and others have recorded involution of the corpus geniculatum externum, pulvinar, and anterior corpora quadrigemina in Man following destructive lesions of the occipital region, and more particularly of the cuneus. He alleges, moreover, that similar lesions of the temporo-sphenoidal lobe in Man cause degeneration of the corpus geniculatum internum, the inferior arm of the corpora quadrigemina, and the posterior corpora quadrigemina themselves.

It has likewise been asserted by Laufer and Forel (see Forel, No. 517, xviii. 1887, p. 183) that in one instance they found diminution in size of the *red nucleus* on one side follow division of the *ascending cerebellar peduncle* on the opposite.

It would seem, moreover, that a sympathetic relationship exists between *cerebrum* and *cerebellum*, in so far at least as destruction of the one may be accompanied by involution of the other. Howden (No. 5, ix. 1875, p. 288) has met with a case where, accompanying a shrinking of the right cerebral hemisphere followed by left hemiplegia with contractures, there was an involution of the left cerebellar lobe. A similar case is recorded by Cramer (No. 492, xi. 1891, p. 39).

Literature on Degenerations following Destruction or Enucleation of the Eyeball. – **Deutschmann** (Lesions resulting from Destruction of Eyeball): Arch. f. Ophthal., xxix. Ab. 1, 1883, p. 323. **Fürstner**: Arch. f. Psych., xii. 1882, p. 611. **Ganser**: Arch. f. Psychiat., xiii. 1882, p. 341. **Gowers**: Centralbl. f. d. med. Wissensch., 1878, p. 562. **v. Gudden**: Arch. f. Ophthal., xx. 1874, Ab. 2, p. 249; *Ibid.*, xxv. 1 Ab., 1879, p. 1. **Hebold**: Arch. f. Ophthal., xxxviii. 1892, p. 221. **Marchand** (Lesions resulting from Destruction of Eyeball): Arch. f. Ophthal., xxviii. Ab. 2, 1882, p. 63. **Michel**: Arch. f. Ophthal., xxii. 1876, p. 245. **v. Monakow**: Arch. f. Psychiat., xiv. 1883, p. 699; *also*, *Ibid.*, xvi. 1885, p. 151 *et seq.* **Purtscher**: Arch. f. Ophthal., xxvi. 1880, Ab. 2, p. 191.

Literature on Degenerations following Amputation of Limbs. — **Dejerine and Mayor**: Bull. de la Soc. de biol., 1878. **Dickinson**: Journ. of Anat. and Physiol., iii. 1868, p. 88. **Dreschfeld**: Journ. Anat. and Physiol., xiv. 1879, p. 424 (with other references). **Edinger**: Arch. f. path. Anat., lxxxix. 1882, p. 46 (with other references). **Hayem and Gilbert** (Spinal Cord after Amputation): Arch. de physiol. norm. et path., iii. 1884, p. 430. **Reynolds** (Changes in Nerv. Syst. after Amputation of Limbs): Brain, ix. 1886-87, p. 494. **Sass**: Arch. f. path. Anat., cxvi. 1889, p. 243. **Vulpian**: Arch. de physiol., 1868 and 1869.

CHAPTER LXXXV

THE NERVOUS SYSTEM—(*Continued*)

ENCEPHALIC TUMOURS.

972. AMONG the commonest are Sarcomata, Gliomata, Secondary Cancers, Gummata, Tubercles, Cysticerci, Echinococcus Cysts, etc.

The sarcomata are of the ordinary types and are often found growing from the membranes and pressing secondarily into the tissue of the brain or spinal cord. In the cord they are sometimes multiple and involve the roots of the spinal nerves. At other times they grow within the brain substance, causing widespread destruction of the parts around.

Primary cancers are rare. If such tumours do occur, the pituitary body, the pineal gland, or the lining epithelium of the ventricle might be looked upon as their starting-point.

Secondary cancers occur in all situations, but most frequently within the area of distribution of the middle cerebral artery. It is to be remembered that when implanted in the brain substance they are sharply circumscribed and easily enucleated tumours.

Some of the most typical **gliomata** have ill-defined borders (see Fig. 465), the swelling, deformity, and slight change of colour induced by them being probably the chief means whereby their locality can be recognised. They are found both in the brain and in the spinal cord. According to R. Volkmann (No. 140, xlii. 1888, p. 433) the nerve cells and fibres become involved in the tumour and suffer degeneration. The axis-cylinder suffers first. It swells and breaks across, giving rise to the usual diaphanous colloid bodies. The nerve cells suffer atrophy, and large numbers of corpora amylacea are found in the neighbourhood.

Schultze (No. 13, cii. 1885, p. 435) was apparently the first to describe an instance of what is now known as **central gliosis of the spinal cord.** The cord was taken from a man twenty-four years old. In its upper part the gray substance was irregular in outline. Around the central canal there was a tissue which resembled the glia, in some parts congested, in others presenting clefts or hæmorrhages. In the lower dorsal region the medulla spinalis was again normal. It was accompanied by spinal meningitis, but there were no indications, such as swollen axis-cylinders or infiltration of the circumferential parts, of myelitis.

Of late, many instances of the disease have been recorded (see Miura, No. 492, xi. 1891, p. 91). The gliomatous mass may stretch throughout the greater part of the length of the cord. It is often accompanied by **syringomyelia.**

A peculiar **sclerotic tumour-like disease** of the brain is sometimes met with which in some respects resembles the lesion of multiple sclerosis. Tumour masses of almost cartilaginous hardness are found scattered through the *cortex of the hemispheres.* In their tumour-like isolation they differ from the mucoid-looking patches of multiple sclerosis, as well as in the fact that they are mostly confined to the cortex and do not tend to surround the lateral ventricles. The medulla oblongata in some of these cases has quite a cartilaginous hardness, but the spinal cord as a rule is not implicated. The disease has been described by Hartdegen, Pollak, Brückner, Pozzi, Greiff, and Fürstner and Stühlinger, and the author has met with several instances of it. Most cases have occurred in the insane; it is sometimes associated with confirmed epilepsy.

The tumours as a rule are from a pea to a hazel-nut in size and may project as warty excrescences from the surface. The pia is occasionally adherent to their surface. Small cystic cavities have been found by Fürstner and Stühlinger associated with them (No. 517, xvii. 1886, p. 1). Microscopically examined, they seem to be caused by an unusual density of the glia.

Cylindromatous endotheliomata are found in various parts of the brain or projecting into the brain from the membranes. Their several characters have already been referred to under the neoplasms. The author lately met with a curious tumour of this kind in a man who for long had been an epileptic. In size it approached that of a large walnut, and it occupied the head of the caudate nucleus. It was sharply circumscribed and, when cut into, had a somewhat rough granular surface, a grayish colour, and a compact consistence. Examined microscopically, the tumour was seen to be composed simply of dense agglomerations around blood-vessels of cell nests in a state of calcification. It might be classified accordingly as a **psammoma.** Psammomata also grow from the choroid plexus, and either hang pendulous in the ventricle or lie deeply embedded in the brain substance.

Cholesteatomata have occasionally been described. Price (No. 192, xxxviii. 1887, p. 24) records such a growth of large size at the base of the brain. It was extremely brittle and contained numerous cholesterine crystals. They are not very uncommon in this situation, and appear in most cases to be tumours which have undergone degeneration of which cholesterine is a product. A good many of them seem to be dead and shrivelled hydatid cysts.

A tumour is found in the horse growing from the choroid plexus into the ventricle having a reticular fibrous structure. The large spaces of the reticulum are filled with cholesterine crystals.

Taubner (No. 13, cx. 1887, p. 95) gives a description of a **lipoma** which grew from the right corpora quadrigemina and processus cerebelli ad corpora quadrigemina. It was the size of a hazel-nut and was entirely composed of ordinary fat.

Tumours of the **adenomatous type** are rare in the brain. They usually occur either in connection with the pineal gland or pituitary body. Coats (No. 192, xxxviii. 1887, p. 44) describes an adenoid sarcoma of the pineal gland containing small pieces of cartilage very like, he says, the cystic sarcoma of the mamma. The tumours of the pituitary body are mostly cystic, the cysts being possessed of gelatinous colloid contents. Virchow called the condition "struma pituitaria." Rarely they bear a more strictly adenomatous type.[1]

Circumscribed tumours composed of **gray matter of the brain** containing pyramidal nerve cells are said by Otto (No. 13, cx. 1887, p. 81) to be met with in the white substance of the cerebrum. They are placed sometimes opposite the highest points of the convolutions, at other times are located at the depths of the fissures and sulci. A similar statement has been made by Simon. Every one who has worked at the brain must be familiar with an appearance of this kind resulting simply from portions of the gray matter having been sliced off irregularly. Whether these are the same as the above it is hard to say.

For account of the condition of the Optics and the so-called "Hypertrophy of the brain" which accompany brain tumours, see pp. 577 and 708.

EPILEPSY.

973. It seems to be well established both from experimental and clinical evidence that convulsions at least, if not true epilepsy, may result from explosions of nerve energy within the motor nerve cells of the cortex cerebri, medulla oblongata, and floor of the fourth ventricle. The name "Cortical or Jacksonian Epilepsy" is given to the convulsions from the first of these causes, while that of "Infracortical or Medullary Epilepsy" is the term employed when they are the result of a discharge of nerve energy from the medulla oblongata and its neighbourhood.

Cortical or Jacksonian Epilepsy.

Epileptiform convulsions in various parts of the body can be excited by the application of a powerful electric current to the motor cerebral cortex of the cat, dog, monkey, or guinea-pig—that is to say, in an animal with a pretty highly-developed cerebrum.

---

[1] For further information see Heusser (No. 13, cx. 1887, p. 9).

According to F. Frank and Pitres (No. 4, xii. 1883, p. 1), the convulsions may manifest themselves as a monospasm of a particular muscular group; sometimes they extend to all the voluntary muscles on one side of the body (hemispasm); and sometimes they affect the muscles of all four members and of the two sides of the face (general epilepsy). The animal appears to preserve its consciousness where the attacks are partial. Where they are general, however, consciousness is lost, the pupils become large and immobile, and do not react to light. Other phenomena very much akin to those of true epilepsy show themselves, and the end of the attack is announced by a deep inspiration.

These phenomena correspond very closely with cortical epilepsy, as originally described by H. Jackson (see Bibliog.). This affection differs from what is called "idiopathic epilepsy" in the fact that the convulsions commence in one isolated muscular group. An habitual epileptic of the congenital type utters a cry, becomes insensible, falls, and is universally convulsed, while the Jacksonian epileptic knows when the attack is commencing, is conscious of the first spasms, and if he become unconscious, is so only later on. There is no characteristic cry, he does not fall at once, but probably has sufficient time to seat himself before the attack has reached its climax. The spasms usually follow a particular order in their advent. Thus, if they begin in the face, they next spread to the arm and subsequently to the leg. If they begin in the hand, they afterwards attack arm and face successively. If they begin in the leg, those of the arm follow, and the face is affected last.

This Jacksonian epilepsy is almost always the result of stimulation of the motor area in the cerebral cortex by tumours, softenings, encephalitis, meningitis, etc. Lesions of the centrum ovale provoke Jacksonian epilepsy only when, at the same time, they implicate the gray matter of the convolutions.

There is a possibility, however, as already mentioned, that discharges of a like kind may take place from parts lower down such as the medulla oblongata and floor of the fourth ventricle. H. Jackson (No. 521, ix. 1887, p. 1) is quite of this opinion—an opinion which is also held by Gowers (No. 525, p. 201). The medulla oblongata in chronic epileptics is sometimes extremely hard and cartilage-like, particularly in the neighbourhood of the olivary bodies. The hardness is due to a coarsely fibrous condition of the part.

Binswanger's experiments (No. 517, xix. 1887, p. 759) also seem to support this view. He finds that in rabbits there are a series of mechanically and electrically excitable points located on either side of the middle line of the floor of the fourth ventricle. When they are stimulated convulsive phenomena are forthcoming in the back, head, and extremities; and not only so but the movements in the extremities have an organised character.

It is quite possible that in the so-called idiopathic or congenital epileptic these centres are concerned. The reflex character of the attacks would lend some colour to the notion, and, moreover, the medulla oblongata in such individuals is seldom free from disease. It is often of cartilage-like hardness, from an overgrowth of fibrous tissue having taken place in its substance (see p. 682).

Artificial Production of the Epileptic Habit in Animals.

Brown-Séquard (see Bibliog.) showed that guinea-pigs could be rendered epileptic by various procedures, such as hemisection of the spinal cord, or by injury, section, or pinching of a sensitive nerve such as the sciatic. In course of time there forms, on the same side of the head and face, on the skin on the inferior border of the lower jaw, on that of the anterior border of the shoulder-blade, or on part of the skin of the nape of the neck, what he termed an "epileptogenous zone." The slightest tap over, or even brushing against, this zone is sufficient to throw the animal for a few seconds into a condition closely resembling epilepsy in the human subject. The fits, from possessing at first the character of a mere reflex spasm, go on increasing in severity until, in the course of something like six weeks, they assume that of true epileptic seizures. Indeed Westphal (No. 43, viii. 1871, p. 449) has demonstrated that, without any previous operation, a simple tapping of the head of a guinea-pig, as with a percussion hammer, is sufficient to throw it, either immediately or in a few seconds afterwards, into convulsions. Instances of a like condition in Man have been reported and commented upon by Nothnagel. They have usually occurred in individuals who have received some injury to the sciatic or fifth nerve.

But the most extraordinary case of this guinea-pig-like epileptic condition on record is that observed by Hughlings Jackson (No. 6, 1886, ii. p. 962). From the care taken to investigate the case there cannot be any doubt that it was genuine. The patient was a boy seven years of age, who appears to have had true epileptic fits off and on from the time when he was two and a half years old. Latterly, however, he developed an "epileptogenous zone" over the head. On flicking the face with a handkerchief, or merely touching the head, or when an object like a curtain came in contact with this zone, the boy collapsed and fell to the ground. He turned red, looked vacant, his respiration ceased, and his eyes were drawn to one side. The "fit" lasted for about fifteen seconds or less. He would sometimes have as many as fifty falls of this kind in a day. He took similar "fits" in his sleep if the head was touched, and the movements were exactly the same as when he was awake.

State of the Nerve Centres during an Attack.

The general opinion is that during an epileptic attack the brain is *anæmic*, and Kussmaul and Tenner's experiments are generally quoted as supporting the view that the starting-point of the epileptic attack is this primary anæmia. The loss of consciousness is also often accounted for on this basis. The anæmia is supposed to originate in vascular spasm.

If a person die during a convulsive fit, the brain will be found anæmic to an extraordinary degree; if some short time afterwards, the vessels contain, as a rule, more blood than usual.

It is hard to explain, if anæmia be the starting-point of the convulsion, how Alexander's operation of ligature of the vertebral artery or arteries (No. 521, v. 1883, p. 170) proves efficacious, as in many cases it seems to be, in at least relieving, if it does not actually eradicate, the epileptic habit of body. Perhaps it may be, as the deviser of the operation suggests, that the ligature of the artery acts by in some way altering the circulation.

Literature on Epilepsy.—**Alexander** (Treatment by Ligature of Cerebral Arteries): Brain, v. 1883, p. 170. **Binswanger** (Pathogenesis): Arch. f. Psychiat., xix. 1888, p. 759. **Brown-Séquard:** Researches on Epilepsy, 1857; *also*, Arch. de physiol. norm. et path., 1868-72. **François-Franck and Pitres:** Arch. de physiol. norm. et path., xii. 1883, p. 1. **Fraser** (Hemi-atrophy of Brain in): Glasg. Med. Journ., xxxi. 1889, p. 83. **Gowers:** Epilepsy and other Chronic Convulsive Diseases, 1881. **Hare:** Epilepsy; its Pathology and Treatment, 1890. **Horsley** (Origin and Seat of Epileptic Disturbance): Brit. Med. Journ., 1892, i. p. 693. **Jackson** (Localisation of Movements): Lancet, i. 1873, pp. 84, 162, 232; *also*, Reprint; *also*, West Riding Asylum Rep., iii. 1873, p. 175; *also* (Partial Convulsion), Med. Times and Gaz., i. 1875, p. 578 *et seq.*; *also*, Lancet, 1877, i. p. 876; *also* (Convulsions), Brain, ix. 1886-87, p. 1. **Jackson and Beevor** (E. with Olf. Aura. Tumour in Temp.-Sph. Lobe): Brit. Med. Journ., 1889, i. p. 414. **Kussmaul and Tenner:** Moleschott's Untersuch., iii. 1857. **Paton** (Jacksonian): Brain, viii. 1885-86, p. 474. **Unverricht** (Experimental): Arch. f. Psychiat., xiv. 1883, p. 175. **Westphal:** Berl. klin. Wochnschr., viii. 1871, p. 449.

DISSEMINATED SCLEROSIS.

974.—*Syn.* Insular sclerosis, Sclérose en plaques disséminées.

Definition.—*A chronic disease characterised by the growth of patches of new connective tissue within the brain, cord, or in both simultaneously. The patches do not follow any regular course in their distribution.*

Historical.—The disease appears to have been first described by Cruveilhier (No. 332), and the appearances presented by the parts were about the same time figured by Carswell (No. 557). It was, however, Charcot (No. 558, p. 157) and Vulpian (No. 559, p. 676) who some twenty-five to thirty years ago first gave us a clear description of its clinical and pathological peculiarities.

Vital Phenomena.—It is a disease which may occur at any period of life, but is rare in childhood and in old age. It may simulate all manner of nervous affections, but among the most striking of its manifestations are the trembling of the arms on the endeavour to perform purposed movements, nystagmus, and a termination in general imbecility. There may be paresis, there is not generally paralysis of the limbs.

Morbid Anatomy and Histology.—The patches of new tissue may be entirely confined to the brain or to the cord, but are sometimes present in both. The cranial nerves, such as the optic, are occasionally involved. The brain presents a shrunken appearance, and its sub-arachnoid spaces are correspondingly large. The patches are quite irregular in shape, and follow no law as to distribution through particular tracts. They are most numerous in the white matter. Charcot supposed that the cerebral cortex escaped. That, however, is not so; the patches may be found here as elsewhere, sometimes strictly

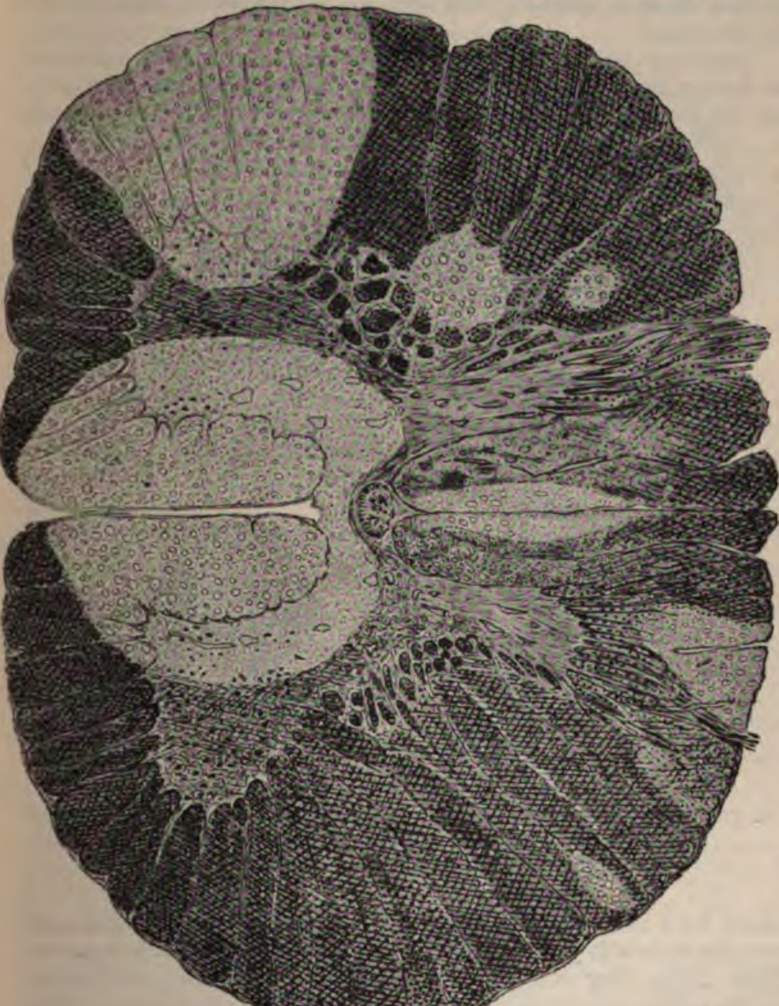


FIG. 470.—SECTION OF THE CERVICAL CORD AFFECTED WITH DISSEMINATED SCLEROSIS (×50 DIAMS., reduced—Hæmatoxylene, Eosin, and Clarified).

confined to it, at other times passing into it from the subjacent white matter.

In the most typical cases there is usually a very large patch closely embracing each lateral ventricle. Within the pons they are numerous, and may lie so superficially that they are readily visible before cutting into the organ.

They may be either soft and gelatinous or somewhat hard. In the former, met with in old-standing cases, the patches look exactly like the myxomatous parts of a mucoid sarcoma. They are sharply defined from their surroundings, are irregularly angular in outline, and have the same soft jelly-like aspect which myxomatous patches possess. While fresh, they are gray or grayish-red in colour, but become redder, more salmon-coloured, on exposure to the atmosphere. They vary in size, from a barley seed to patches several centimètres in length, and when cut into are level with the surface. Within the cord the patches are very numerous. They are sometimes wedge-shaped, the base of the wedge towards the periphery. The patch may run inwards from the white and nip off a semilunar piece of the gray matter, or it may implicate the entire anterior or posterior horn,

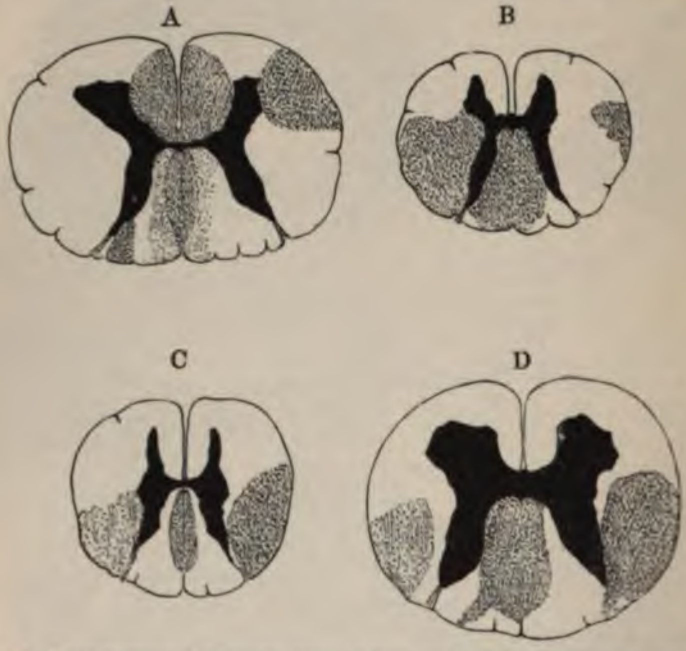


FIG. 471.—HALF SCHEMATIC REPRESENTATIONS OF CORD IN DISSEMINATED SCLEROSIS SHOWING THE POSITION OF THE SCLEROTIC PATCHES AT DIFFERENT LEVELS.

(A) Cervical; (B) upper dorsal; (C) lower dorsal; (D) lumbar.

possibly, along with the surrounding white matter. Sometimes a crescentic patch is placed symmetrically on either side of the anterior fissure.

Examined microscopically, the glia within each patch is found to be densely cellular, so that when a suitable staining reagent, such as hæmatoxylene, is used, the border of the patch is seen to be sharply demarcated from the neighbouring parts, owing to its deep colour.

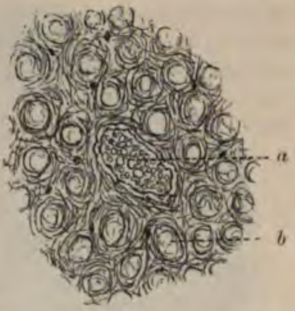


FIG. 472.—PART OF A SCLEROTIC PATCH FROM A SPINAL CORD AFFECTED WITH INSULAR SCLEROSIS SHOWING THE FELT-LIKE PLEXUS OF FINE CONNECTIVE TISSUE FIBRES BETWEEN THE NERVE TUBES (×300 DIAMS.)

(*a*) Blood-vessel; (*b*) nerve tube surrounded by the new growth of connective tissue (Logwood and Clarified).

Every one (see Bibliog.) now seems to be agreed that the medullary sheath of the nerve fibres degenerates, but that the axis-cylinder may preserve its continuity for long, even in its naked state. Hence, probably, the absence of paralysis in the early stages. There is also usually no evidence of secondary degeneration, probably for the same reason. The nerve cells preserve their integrity. When secondary degeneration is noticed it is in keeping with the number of axis-cylinders destroyed (Babinski, No. 4, v. 1885, p. 186).

In the centre of each patch a large vessel may be seen; it is often a vein. Around it may be observed an unusually dense small-cell infiltration.

Nature of Morbid Lesion.—It has been supposed to be a localised encephalitis or myelitis. Charcot, Vulpian, and Fromann trace its commencement to the neuroglia. Rindfleisch supposed that it took its departure from the adventitia of the blood-vessels. Adamkiewicz, on the other hand, believes that it is a primary affection of the nerve tubes.

Literature on Multiple Sclerosis.—**Babinski**: Arch. de physiol. norm. et path., v. 1885, p. 186. **Bastian**: Trans. Clin. Soc. Lond., xvii. 1884. **Brückner**: Arch. f. Psychiat., xii. 1881-82, p. 550. **Bruns**: Berl. klin. Wochnschr., xxv. 1888, p. 90. **Buchwald**: Ueb. mult. Sklerose des Hirns u. Rückenmarks, 1872. **Buss**: Berl. klin. Wochnschr., xxiv. 1887, pp. 921, 945; *also*, Deut. Arch. f. klin. Med., xlv. 1889, p. 555. **Charcot**: Lectures on Nervous System, N. Syd. Soc. **Cramer** (Commencing): Arch. f. Psychiat., xix. 1888, p. 667. **Duplaix**: Arch. gén. de méd., 1885, i. pp. 145, 314. **Ebstein**: Ueb. mult. Sklerose, etc., 1886. **Gilbert and Lion**: Arch. de physiol. norm. et path., x. 1887, p. 126. **Glynn**: Liverp. Med.-Chir. Journ., vii. 1887, p. 192. **Hess**: Arch. f. Psychiat., xix. 1887, p. 64. **Jolly**: Arch. f. Psychiat., iii. 1872, p. 711. **Köppen** (Histol. Changes): Arch. f. Psychiat., xvii. 1886, p. 63. **Oppenheim**: Berl. klin. Wochnschr., xxiv. 1887, p. 904. **Osler**: Canada Med. and Surg. Journ., ix. 1880-81, p. 1; *also*, Reprint. **Pelizaeus**: Arch. f. Psychiat., xvi. 1885, p. 698. **Ribbert**: Arch. f. path. Anat., xc. 1882, p. 243. **Schuster** (Following Syph.): Deut. med. Wochnschr., xi. 1885, p. 878. **Tjaden**: Ein Beitrag zur Kenntniss der mult. Sclerose, etc. **Unger**: Ueb. multiple inselförmige Sklerose des Centralnervensystems in Kindesalter. **Vulpian**: Maladies du système nerveux, ii. 1886, p. 676.

LOCOMOTOR ATAXIA.

975. **Definition.**—This disease is characterised essentially by *loss of the power of co-ordinating the movements of the lower and it may be the upper extremities for combined actions, as in walking*, etc. Later on, certain complications show themselves, such as loss of the reflexes for the vesical and intestinal sphincters, squint, ptosis, double vision, mydriasis, myosis, amblyopia, amaurosis, colour-blindness, etc.

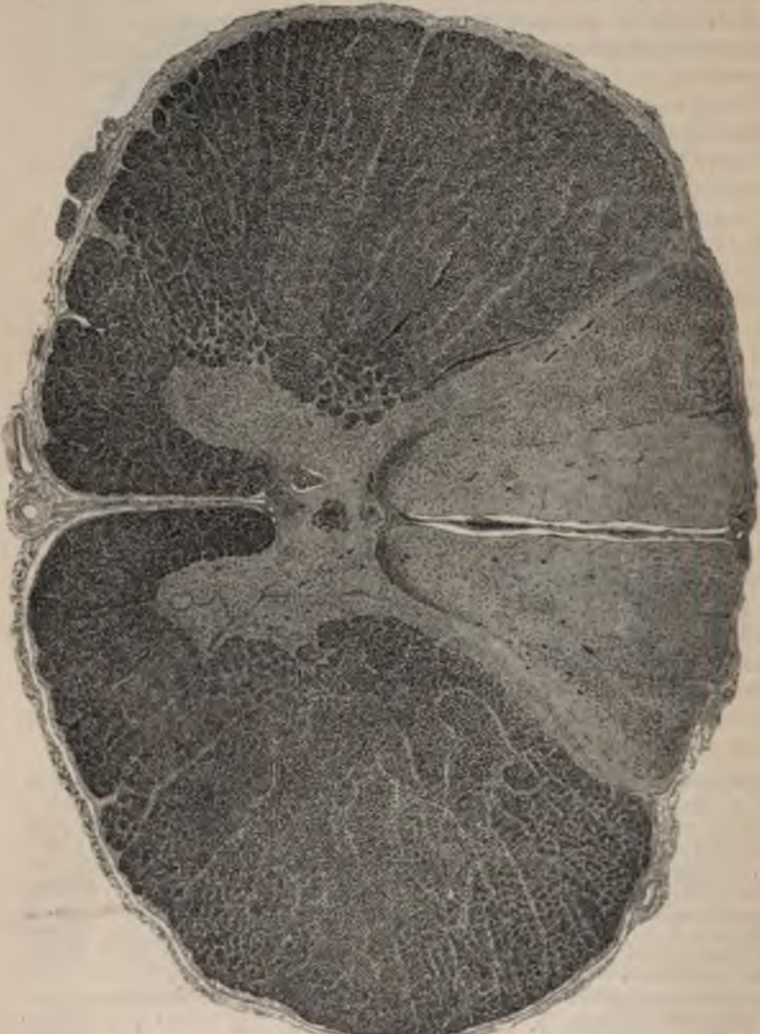


FIG. 473.—SECTION OF CORD AFFECTED WITH LOCOMOTOR ATAXIA. SCLEROSIS OF THE POSTERIOR COLUMNS. LOWER DORSAL REGION (×50 DIAMS. reduced—Weigert's Hæmatoxylene Stain).

Sex.—It is a disease more common in the male than in the female, about 10 per cent only being females. It is also usually a disease of middle life.

Nature of Disease.—The symptoms are due to a characteristic lesion, a sclerosis, of the posterior columns of the cord (Fig. 473). The glia increases in quantity and becomes very fibrous, so that if a small piece of the degenerated tracts be cut off and squeezed out under a cover-slip, quite a felt-work of delicate fibres comes into view (Fig. 474).

The nerve fibres are destroyed at an early period, and the destruction implicates axis-cylinder as well as medullary sheath. Varicose swellings may be found on the axis-cylinders during the time that they are breaking up.

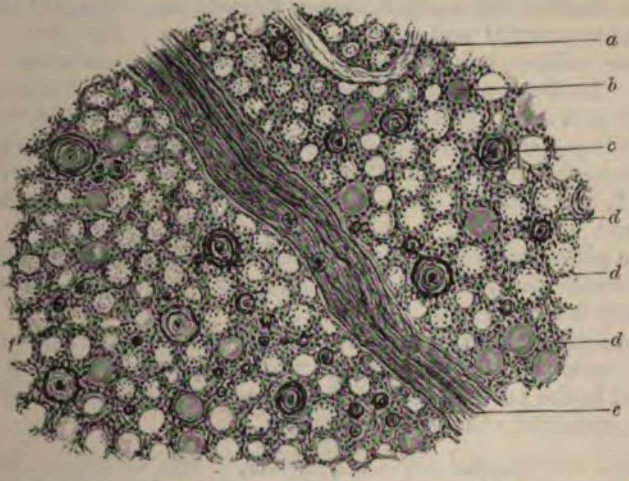


FIG. 474.—SCLEROSIS OF THE POSTERIOR COLUMNS OF THE CORD IN LOCOMOTOR ATAXIA (×300 DIAMS.)

(*a*) Capillary vessel; (*b*) colloid bodies (*c*) nerve tubes in state of degeneration; (*d*, *d*, *d*) sclerotic tissue lying between nerve tubes, the sheaths of most of which are empty; (*e*) interfunicular artery (Logwood, Picric acid, and Clarified).

Large numbers of true amyloid bodies are seen lying in the degenerated parts. Their presence is in some respects a distinctive feature of the lesion. The degeneration is usually regarded as belonging to the class of "system diseases" of the cord—that is to say, it is a degeneration commencing in a particular tract, and running along it upwards or downwards, while other tracts remain uninjured. It should be remembered, however, that this view is not universal.

Adamkiewicz, for instance (No. 12, lxxxiv. H. 1, Ab. III. 1881, p. 469; and *Ibid.*, xc. H. 1, Ab. III. 1885, p. 258) holds that it is not a disease guided in its direction by any particular tract, but that the course of the sclerosis is determined by certain blood-vessels, more particularly the interfunicular arteries of the posterior columns.

Seat of Origin of Lesion and Parts affected.—The sclerosis usually commences in the *lower dorsal* and *upper lumbar regions*, and spreads upwards. It is questionable, nevertheless, whether the disease in the cervical portion of the cord is always of the same nature as that lower down. In many instances it has more the character of a secondary degeneration following upon destruction of the ascending lumbar fibres, and corresponds in extent and site to their position in the cervical cord.

The degeneration begins as a rule in the *posterior root zone*, and the *posterior roots* are also implicated. It must not be supposed, however, that the posterior root zone is always the seat of advent of the disease. At the primary locus of the disease in the inferior dorsal region the sclerosis is often best marked *around the interfunicular artery*, between the postero-internal and postero-external tracts. The fibres of the posterior column lying close to the posterior commissure usually escape. In the upper cervical region the lesion may be found strictly confined to a *small wedge-shaped area within the tracts of Goll* on either side of the posterior fissure. *Lissauer's tract* is almost always implicated (see Nonne, No. 517, xix. 1887, p. 810; and Hadden and Sherrington, No. 521, xi. 1889, p. 330). *Clarke's vesicular columns* are generally destroyed.

The *pia mater* over the degenerated tracts is sometimes thickened. The *muscular coat of the arteries* suffers great hypertrophy and becomes peculiarly homogeneous.

The anterior horn of gray matter and the anterior nerve roots as a rule remain unaffected. The degeneration, however, is not always confined to the posterior columns. Towards the climax of the disease it may spread into the *lateral columns*.

Hadden and Sherrington (No. 521, xi. 1889, p. 325), for instance, describe a case of this kind in which an ascending degeneration could be traced throughout the course of the lateral columns from the lowest limits of the cord upwards through the medulla oblongata. Bullen (No. 521, xii. 1890, p. 433) records another case. In this there was slight degeneration of the crossed pyramidal tracts throughout the entire dorsal region, while the anterior cornua and anterior nerve roots were unchanged. In the former case the degenerated fibres in the lumbar and lower dorsal regions were spread out diffusely, but in the upper dorsal and cervical regions the tract of degeneration was more defined, and occupied the so-called "antero-lateral tract" of Gowers in a position midway between anterior and posterior nerve roots. In the medulla, it lay in front of the substantia gelatinosa—a position also occupied by the direct cerebellar tract in its course upwards. For such, and for other reasons, Hadden and Sherrington hold that this antero-lateral tract is simply the anterior portion of the direct cerebellar tract.

The *peripheral nerves* almost always suffer in cases of old standing. Among those to be first affected are the optic and the third. The degeneration within them seems to resemble that of the spinal cord. It is accompanied by complete breaking up of the nerve fibres.

Friedreich (No. 13, xxvi. 1863, pp. 399, 452), Westphal (No. 517,

viii. 1878, p. 480), Dejérine (No. 4, ii. 1883, p. 72), Sakaky (No. 517, xv. 1884, p. 584), and Nonne (No. 517, xix. 1887, p. 809) have all described degeneration of peripheral spinal nerves, more especially such as are sensory-cutaneous. Langhans, however (No. 13, xlv. 1869, p. 413), states that the tactile corpuscles of the skin are uninjured.

In some very old-standing cases the *heads of the bones* become absorbed and the *long bones* deformed (Charcot's disease). It is possible that this may be caused by a degeneration of peripheral nerves. The teeth also sometimes fall out, probably for a like reason.

Where the muscles begin to fall off the anterior horns of gray matter will usually be found diseased.

Gastric and Laryngeal Crises.—The so-called "gastric crises" are difficult to account for on pathological grounds. Ross (No. 521, ix. 1887, p. 24) relates a case where there were "laryngeal crises" with crowing respiration and tendency to suffocation. They were associated with a completely disorganised condition of the *fasciculus rotundus* in the medulla oblongata on both sides, and with minor changes in the ascending root of the fifth.

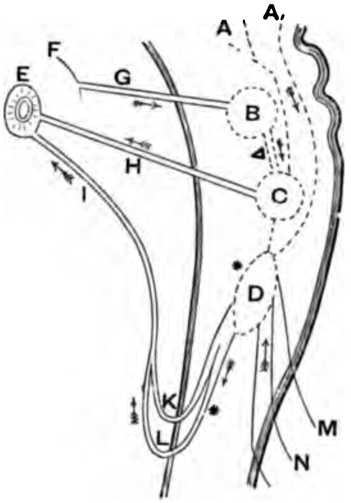


FIG. 475.—ERB'S SCHEME ILLUSTRATING THE MECHANISM OF THE ARGYLL-ROBERTSON PHENOMENON (see Text).

Pupil Phenomena.—A peculiar pupil phenomenon, first described by Argyll-Robertson (No. 19, xiv. 1868-69, p. 697), is often noticed in the course of the disease. It consists in the absence of reflex contraction to light, while contraction in the act of accommodation is retained.

Erb's explanation (No. 140, xxiv. 1879, p. 1), which is the one usually adopted, is the following (see Fig. 475):—The light reflex of the pupil is held by him to be regulated by the arc GBCH. A lesion of the optic nerve (G) will cut off the light reflex, but will also be accompanied by blindness. Disease of the fibres of the third (H) will have the same effect on the pupil, but will be accompanied by dilatation of the pupil and loss of contraction of the pupil in accommodation. Destruction of the fibres (Δ) connecting the corpora quadrigemina and the nucleus of the third nerve will arrest the light reflex, and the loss of reaction will not be accompanied by either blindness or paralysis of the sphincter of the iris. Contraction to accommodation will also be retained, because the path A will still be open. The seat of the lesion underlying this peculiar pupil phenomenon ought therefore to be in a path corresponding to Δ—that is to say, at a point somewhere intermediate between the anterior corpora quadrigemina and the floor of the aqueduct.

Cause of Incoordination.—It is probably due simply to the loss or impairment of the reflexes necessary for locomotion, together with a greater or less amount of impairment of tactile sensibility. The loss in control over the sphincters which ensues in the later stages of the disease can be explained on the same grounds. Van Deen and Cl. Bernard demonstrated that section of the posterior nerve roots induces total inability to co-ordinate movement; while, of late, two cases have been recorded by Dejérine (No. 4, iii. 1884, p. 231) in which the ataxy was the result of neuritis; and one by Bennett (No. 293, xviii. 1885, p. 168) in which locomotor ataxia of spinal origin was completely simulated by multiple sarcomatous tumours pressing upon the posterior nerve-roots.

The **lightning pains** and delay in transmission of painful impressions are to be explained on a like basis. The fact of the peculiar darting pains coming on early in the disease is accounted for by the sclerosis so often commencing in the posterior nerve-root zone.

The **absence of paralysis** of motion is due to the anterolateral columns, the anterior cornua of gray matter, and the anterior nerve roots being spared.

Syphilitic Origin.—It has often been asserted that the exciting agent in locomotor ataxia is syphilis. Fournier (No. 134, ccix. 1886, p. 200) has made careful inquiry into the matter, and his statistics show that out of 146 cases of locomotor ataxia, 9 were without syphilitic antecedents; 22 were doubtful, *i.e.* had suffered from a venereal sore, but whether syphilitic or not could not be ascertained; 112 had undoubtedly suffered from syphilis; and 3 apparently were hereditarily syphilitic.

Ataxic Paraplegia.—A peculiar form of ataxia is sometimes seen where, in addition to many of the ordinary ataxic phenomena, there are superadded those of diminished muscular power. The two often develop *pari passu.* The lightning pains and the Argyll-Robertson pupil are usually absent. The cord presents sclerotic alteration both in the posterior and lateral columns; the degeneration in the latter situation may be sharply circumscribed to the crossed pyramidal tract. As referred to by Gowers, however (No. 59, 1886, ii. p. 2), there are two distinct points of difference in the anatomical lesions in this as compared with locomotor ataxia pure and simple. These are (1) that the sclerosis of the posterior columns is ill marked in the lumbar but evident in the dorsal region of the cord; and (2) that the sclerosis is rarely so intense in the posterior root zone.

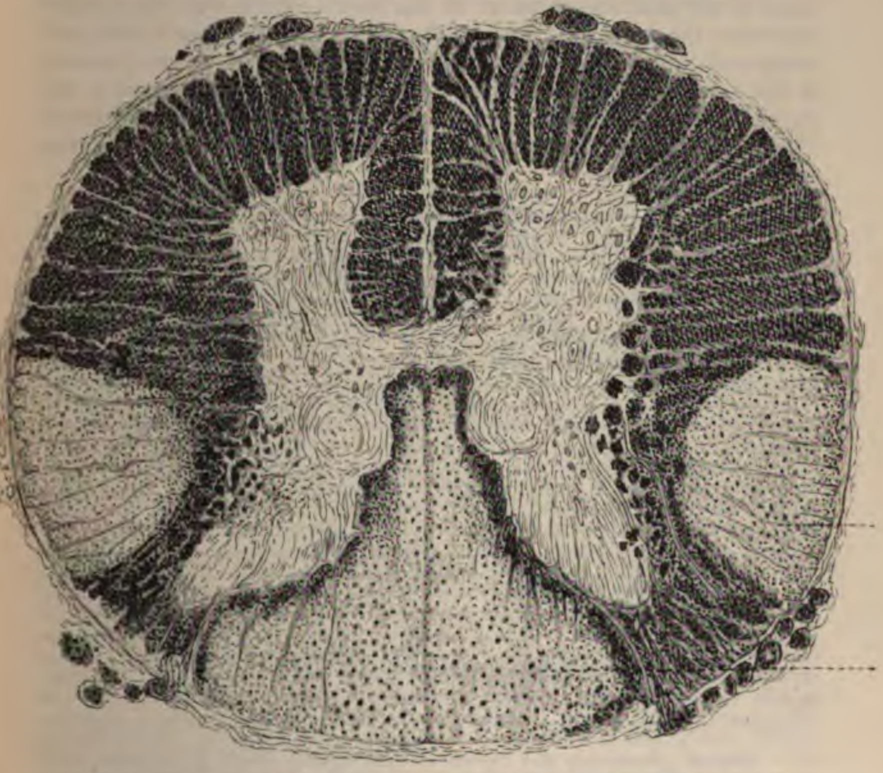


FIG. 476.—SECTION OF CORD AFFECTED WITH THE SCLEROSIS OF FRIEDREICH'S DISEASE.

The patches are confined to the posterior and lateral columns. Upper lumbar region (×50 Diams., reduced—Weigert's Hæmatoxylene Stain).

Ataxia and Bulbar Paralysis.—Locomotor ataxia ends occasionally in bulbar paralysis, with atrophy of the bulbar nerves.

FRIEDREICH'S DISEASE (*Hereditary Ataxia*).

976. **Definition.**—By this is understood *a hereditary form of ataxia usually affecting several members of a family.* The age at which it shows itself varies from four to twenty-four years (Gowers). Fried-

reich classified it with locomotor ataxia, Charcot and Bournville with disseminated sclerosis.

Nature of Lesion.—In all well-authenticated cases, according to Friedreich (No. 13, lxx. 1877, p. 140), the most manifest lesion is sclerosis of the posterior columns, sometimes affecting both those of Burdach and of Goll. In addition to this, sclerosis is found in the other columns, sometimes in the posterior part of the lateral, at other times in the anterior columns. In the lateral column the degeneration may take the form of a wedge (Fig. 476), with the base to the periphery and the apex pointing towards the bay formed by the junction of the anterior and posterior gray cornua. Friedreich regarded the cord lesions as primary, not secondary. He also stated (No. 13, lxviii. 1876, p. 177) that the lesions of the posterior columns cease in the medulla oblongata.

Literature on Locomotor Ataxia.—**Adamkiewicz:** Arch. f. Psychiat., x. 1880, p. 767; *also* (Anatomy), Sitzungsb. d. k. k. Akad. d. Wissensch., Math.-naturw. Cl., 1884, Wien, 1885, xc. p. 258. **Althaus:** Progressive Locomotor Ataxy, 1866. **Bennett** (Without Dis. of Post. Cols.): Trans. Cl. Soc. Lond., xviii. 1885, p. 168. **Bramwell** (With Loss of Musc. Sense): Brain, x. 1887-88, p. 218. **Brown:** Brain, xv. 1892, p. 250. **Bullen** (L. A. with Gen. Paralysis): Brain, xii. 1889-90, p. 433. **Charcot** (Joint-Lesions): Arch. de physiol. norm. et path., ii. 1869, p. 121; vi. 1874, p. 166; *also*, Bull. Soc. anat. de Par., l. 1875, p. 546. **Charcot and Joffroy:** Arch. de physiol. norm. et path., iii. 1870, p. 306. **Dreschfeld** (Friedreich's Disease): Manchest. and Liverp. Hosp. Rep., iv. 1876, p. 93. **Dreyfuss** (Paralysis of Larynx in): Arch. f. path. Anat., cxx. 1890, p. 154. **Duchenne:** Arch. gén. de méd., 1858, ii. p. 641; 1859, i. pp. 36, 158, 417; 1863, ii. p. 570; *also* (Sympathetic in), Gaz. hebd. de méd. et de chir., i. 1864, pp. 116, 147; *also*, Collected Works, N. Syd. Soc., 1883. **Eichorst:** Arch. f. path. Anat., cxxv. 1891, p. 25. **Erb** (Etiology of Tabes): Samml. klin. Vortr., 1892, No. 53 (Innere Med., No. 18, p. 515). **Eulenburg:** Arch. f. path. Anat., xcix. 1885, p. 18. **Everett Smith** (Friedreich's Disease): Boston Med. and Surg. Journ., 15th Oct. 1885. **Flechsig** (is L. A. a "System-Disease"): Neurol. Centralbl., ix. 1890, pp. 33, 72. **Friedreich** (Hereditary Form): Arch. f. path. Anat., lxviii. 1876, p. 145; lxx. 1877, p. 140. **Goldscheider** (Ataxy and Muscle Sense): Arch. f. Physiol., 1887, p. 491. **Goodhart** (Hereditary): Trans. Clin. Soc. Lond., xxi. 1888, p. 268. **Gowers** (Ataxic Paraplegia): Lancet, 1886, ii. pp. 1, 61. **Hadden and Sherrington:** Brain, xi. 1888-89, p. 325. **v. Kahlden** (Arthropathy in): Arch. f. path. Anat., cix. 1887, p. 318. **Kahler and Pick** (Ataxic Paraplegia): Arch. f. Psychiat., viii. 1878, p. 251; *Ibid.*, x. 1880, p. 179. **Lissauer** (Path. Anat.): Neurol. Centralbl., iv. 1885, p. 245; *also* (Course of Fibres in Post. Horn): Arch. f. Psychiat., xvii. 1886, p. 377. **Menzel** (Hereditary and Disease of Cerebellum): Arch. f. Psychiat., xxii. 1890, p. 160. **Möbius** (New Researches on): Schmidts' Jahrb., ccix. 1886, p. 200. **Nonne** (Periph. Nerves in): Arch. f. Psychiat., xix. 1887, p. 809. **Oppenheim:** Arch. f. Psychiat., xx. 1888, p. 131. **Oppenheim and Siemerling:** Arch. f. Psychiat., xviii. 1887, p. 98. **Redlich** (Post. Roots of Sp. Cord and Tabes): Jahrb. f. Psychiatrie, xi. 1892-93, p. 333. **Reumont:** Syphilis u. Tabes, 1881. **Rindfleisch** (Path. Anat. of): Cong. f. innere Med., Wiesb., vi. 1887, p. 100. **Robinson** (Drawings of Joint Affection): Trans. Path. Soc. Lond., xxxviii. 1887, p. 319. **Ross** (Laryngeal Crises): Brain, ix. 1887, p. 24. **Rossolymmo** (Trophic Lesions Skin): Arch. f. Psychiat., xv. 1884, p. 722. **Shaw** (Peripheral Nerves): Journ. Nerv. and Ment. Dis., N. Y., xv. 1888, p. 433. **Spitzka** (Relations between Symptoms and Lesions): Alienist and Neurologist, vi. No. 3. **Stewart** (Gastric Crisis in): Med. Times and Gaz., 1876, ii. p. 414; *also* (Eye-Phenomena in), Brain, 1879, ii. p. 181; *also* (Eye Symptoms), Brain, ii. 1880, p. 181. **Strümpell:** Arch. f. Psychiat., x. 1880, p. 676; xi. 1881, p. 27; xii. 1882, p. 723. **Suckling** (Friedreich's Disease): Ill. Med. News, Lond., iv. 1889, p. 257. **Westphal:** Arch. f. Psychiat., xvii. 1886, p. 547. **White** (Recent Researches): Brain, ix. 1886-87, p. 396.

POLIOMYELITIS ANTERIOR (*πόλιος, gray*).

977. **Meaning of Term.**—This term is applied to what is supposed to be an inflammatory affection of the anterior horn of gray matter. The disease comes on sometimes acutely, at other times very slowly and insidiously. In accordance with this the following clinical varieties are recognised. In the whole of them the ultimate lesion of the cord is probably identical.

(1) *Infantile Spinal Paralysis—Essential Paralysis—Poliomyelitis anterior acuta infantum.*

The disease passes through three stages—(*a*) the period of acute fever in which the paralysis supervenes; (*b*) the period in which the fever has vanished and in which the paralysis becomes stationary and the muscles undergo atrophy; and (*c*) the stage in which deformities of the limbs present themselves. It seldom proves fatal in childhood.

The **anatomical lesion** consists in an acute destruction of the tropho-motor nerve cells in one or in both anterior horns of gray matter. Although the symptoms at first may point to the disease being more or less general, the destruction of the nerve cells is usually localised to the cervical or lumbar swelling. The glia cells in the affected horn of gray matter are said to be increased in number. Empty spaces are left where the nerve cells have vanished, and in course of time the anterior roots appear to be more or less completely broken up. Later on, the part of the gray matter implicated becomes very fibrous, and the contraction of this fibrous tissue brings about a shrinking of the horn with a depression of the corresponding anterior root zone.

The disease is usually regarded as inflammatory, but on reflection it will be seen that the appearances are by no means those of an ordinary myelitis (p. 582). The fact of its being so peculiarly localised is against the inflammatory theory.

Cerebral Variety.—Infantile paralysis does not always seem to be due to a spinal lesion. It has long been known that it is occasionally of cerebral origin. The supposition was formerly that in these cases a hæmorrhage had occurred in infancy, and that this explained the shrinkage of the brain sometimes found later on.

Jendrassik and Marie (No. 4, v. 1885, p. 105) and Strümpell (No. 93, 1884, No. xliv. quoted by Hoven) seem to have first drawn attention to a disease of the brain supposed to be an *encephalitis*, alike with that of the anterior cornua of the cord in ordinary spinal infantile paralysis. Strümpell named the condition "Polio-encephalitis." This appears to account for a large proportion of these cases. When the individual lives over the acute stage the cortex of the motor area of the brain always shows multiple destructive lesions of a porencephalic nature.

In a good many instances, however, hæmorrhages, softenings, etc., account for the phenomena (compare Ross, No. 521, v. 1883, p. 344).

Seeing that the destruction of the cortex, from whatever cause, is usually localised to small areas, particular muscles or groups of muscles, as might be expected, become paralysed and ultimately contracted. The disease comes on during infancy or early childhood, and is usually ushered in by convulsions.

Ross (No. 521, v. 1883, p. 344) draws a distinction between the condition of the muscles in this and in infantile spinal paralysis. In this they are contracted or contractured, and the limbs consequently assume characteristic positions. In ordinary infantile paralysis they are relaxed and flabby.

In by far the greater number of cases essential paralysis is a disease of infancy or early childhood. It should be remembered, however, that an identical disease is occasionally met with in the adult.

(2) *Poliomyelitis subacuta s. chronica—Wasting Palsy—Paralysie générale spinale antérieure subaiguë* (Duchenne)—*Progressive Spinal Muscular Atrophy.*

Vital Phenomena.—A feeling of weakness is first experienced in the muscles of the upper extremity; wasting in these muscles, beginning usually in the interossei and muscles of the ball of the thumb, and spreading upwards to those of the thorax and trunk, follows; while the disease is slowly progressive and invariably ends fatally.

Morbid Anatomy.—The lesion is essentially the same as in the foregoing. It is seldom that all the nerve cells vanish from the anterior horn; the defect is rather confined to individual groups. It may happen, however, as in the case recorded by Oppenheim (No. 517, xix. 1887, p. 381), that they have completely disappeared.

The muscles lose colour and fall off markedly in bulk. The fibres become fatty, but more as a secondary affection than as a primary condition. The first alteration noticed in the muscles appears to be a proliferation of the connective tissue (perimysium). This is followed in time by fatty destruction of the fibre. In the later stages of the disease the interspaces of the muscular bundles may be filled with adipose tissue.

Literature on Poliomyelitis, Anterior acuta, and Chronica—Infantile Paralysis.—**Bernhardt** (Spastic Cerebral Par. in Children): Arch. f. path. Anat., cii. 1885, p. 26; *also* (Juvenile Prog. Musc. Atrophy, with Implication of Eye Muscles), Berl. klin. Wochnschr., xxiv. 1887, p. 763. **Damaschino** (Path. Anat.): Gaz. d. hôp., lviii. 1885, p. 625. **Duchenne**: L'electrisation localisee, 1872. **Erb**: Cyclopædia of Practical Med. (Ziemssen), xiii. **Gibbons**: Med. Times and Gaz., 1885, ii. p. 307. **Gibney** (Cerebral Par. in Children): N. Y. Med. Rec., xxx. 1886, p. 393. **Gowers** (Birth Palsies): Lancet, 1888, i. p. 709. **Hadden**: Brain, vi. 1883-84, p. 302. **Hoven**: Beitrag zur Anat. der cerebralen Kinderlahmung, 1887; *also* (Cerebral Infantile Paralysis), Arch. f. Psychiat., xix. 1888, p. 563. **v. Kahlden**: Beitr. z. path. Anat. u. z. Allg. Path., xiii. 1893, p. 113. **Kast** (Cerebral Infantile

Paralysis): Arch. f. Psychiat., xviii. 1887, p. 437. **Oppenheim** (Chronic): Arch. f. Psychiat., xix. 1887, p. 381. **Pasteur** (Infant. Par. limited to Bulbar Nuclei): Lancet, 1887, ii. p. 858. **Rockwell** (In Adult): N. Y. Med. Rec., xxvii. 1885, p. 205. **Ross**: Brain, 1882 and 1883. **Seeligmüller** (Birth Palsies): Berl. klin. Wochnschr., xi. 1874, pp. 500, 517. **Wallenburg**: Ein Beitrag zur Lehre von den cerebralen Kinderlähmungen, 1886; *also* (Infantile), Arch. f. Psychiat., xix. 1888, p. 297. **Williamson** (Early Changes): Med. Chron., Manchester, xii. 1890-91, p. 454. **Wolfenden** (Infant. Cerebral Par.): Practitioner, xxxvii. 1886, p. 161.

Erb's Paralysis.

978. This term is applied to a condition in which there is atrophy of the muscles as in the above, but where the atrophy of the muscles is limited to those of the shoulder-girdle and arms, in some cases affecting also those of the thigh, while the forearms and hands are free. The juvenile form of the disease is apparently a primary myotic affection.

Muscular Atrophies.

979. As muscular atrophy plays so prominent a part in poliomyelitis, it may be as well to draw attention to some facts connected with muscular atrophies in general.

Lesions of the brain, as a rule, do not cause muscular atrophy so long as the trophic nerve cells of the anterior horn of gray matter are intact. It is the separation of the muscle from its trophic nerve cell which acts as the commonest cause of muscular atrophy in nervous diseases.

Dreschfeld (No. 521, viii. 1886, p. 164) makes the following classification :—

(1) *Such as result from a primary affection of the motor nerve cells in the anterior horn of gray matter* in the cord—either inflammatory or degenerative. To this group belong infantile paralysis and acute poliomyelitis of adults, progressive muscular atrophy, subacute and chronic poliomyelitis, and amyotrophic lateral sclerosis. The degeneration of the nuclei of the motor cranial nerves is the starting-point of the muscular atrophy of acute and chronic bulbar paralysis (glosso-labial pharyngeal paralysis, and Wernicke's polio-encephalitis superior, acute and chronic). The ophthalmoplegia of Hutchinson and Mauthner is also probably to be included in this category.

(2) *Where the spinal cord is found normal and the lesion resides chiefly in peripheric and intermuscular nerves.* The effect of the morbid condition of the nerve is to separate the muscles from their trophic nerve cells in the spinal cord. Within this group are to be included the multiple peripheric neuritis of Leyden, lead paralysis with atrophy, alcoholic paralysis, and some at least of the paralyses and atrophies following diphtheria, typhoid, and other zymotic diseases. The condition of the limbs in Beri-Beri and that resulting from wounds of nerves or pressure of tumours upon them are also to be reckoned in this group.

(3) In this *the muscles themselves are the primary seat of the affection.* It includes the juvenile form of Erb's paralysis, that of Charcot, and that of Dejérine, and pseudo-hypertrophic paralysis.

(4) *Reflex atrophies* are now acknowledged. Charcot has made a special study of those associated with joint-affections. It is assumed that the trophic ganglia are irritated in a reflex way by the peripheral stimulus.

Charcot and Dejérine describe a primary atrophic affection of the muscles of the face.

THOMSEN'S DISEASE (*Myotonia congenita*).

980. This name is applied to a congenital condition in which there is tonic contraction of the muscles, sometimes of the whole body, but more especially those of the hands and feet. The contraction is most marked on commencing a particular movement, as in going upstairs, and in a manner wears off as the movement is continued. The disease appears to be hereditary. Thomsen, who himself was a sufferer from it, traced it in his family through five generations. It commences in early childhood, and the symptoms become more marked with increasing years.

So far, little is known of its pathology. The only definite observations are those of Erb, and of Martius and Hansemann (see Bibliog.) on the state of the muscles. They found the primitive bundles in a state of hypertrophy, with increase in the number of the nuclei, decreased evidence of striation, and vacuolation (Erb).

Literature on Thomsen's Disease (*Myotonia congenita*).—**Banham:** Brain, x. 1887-88, p. 229. **Buzzard:** Lancet, 1887, i. p. 972. **Cook and Smeeten:** Brit. Med. Journ., 1890, i. p. 73. **Dana:** Journ. Nerv. and Ment. Dis., N. Y., xv. 1888, p. 259. **Erb:** Die Thomsen'sche Krankheit, 1886; *also*, Deut. Arch. f. klin. Med., xlv. 1889, p. 529. **Eulenburg and Melchert** (In Four Sisters): Berl. klin. Wochnschr., xxii. 1885, p. 605. **Greiner:** Étude sur la maladie de Thomsen, 1890. **Hammond:** Gaillard's Med. Journ., N. Y., xli. 1886, p. 614. **Martius and Hansemann:** Arch. f. path. Anat., cxvii. 1889, p. 587. **Moyer:** Med. News, Phila., lvii. 1890, p. 168. **Seifert:** Deut. Arch. f. klin. Med., xlvii. 1890, p. 127. **Thomsen:** Centralbl. f. Nervenh., viii. 1885, p. 193. **White:** Guy's Hosp. Rep., xxxi. 1889, p. 329.

PSEUDOMUSCULAR HYPERTROPHY (*Atrophia musculorum lipomatosa*).

981. The disease is characterised by the apparent great hypertrophy of the muscles of the legs and buttocks, accompanied by progressive weakness in the affected limbs and a peculiar straddling gait.

It seems to be primarily an affection of the muscles at fault, for although alterations of a pathological nature have been found in the spinal cord, yet they are by no means of constant occurrence, nor do they involve definite parts. They vary also in their nature. The anterior nerve roots, it is said, suffer partial disintegration.

The condition of the muscles, such as those of the calf, is alleged to be one in which there is a proliferation of the connective tissue nuclei between the bundles and also of those of the sarcolemma. These increase to such an extent that the muscular fibres suffer atrophy, and certain of them assume the broken-up colloid aspect of the flat abdominal and thigh muscles in typhoid fever. Later on, the new-formed cells become infiltrated with oil and converted into true adipose tissue.

Literature on Pseudo-Hypertrophic Paralysis.—**Berger**: Arch. f. Psychiat., xiv. 1883, p. 625. **Charcot** (State of Muscles): Arch. de physiol. norm. et path., iv. 1871, p. 228. **Clarke and Gowers**: Lancet, 1874, i. p. 801. **Cohnheim**: Ges. Abhandl., 1885, p. 87. **Duchenne**: Brit. Med. Journ., 1867, ii. p. 541; *also*, Arch. gén. de méd., xi. 1868, pp. 5, 179, 421, 552; *also* (Path. Anat.), Gaz. d. hôp., xlv. 1872, p. 634. **Fawsitt** (First Stage): Lancet, 1887, ii. p. 758. **Gowers**: Lancet, 1879, ii. p. 1 *et seq.* **Handford**: Trans. Path. Soc. Lond., xl. 1888-89, p. 24. **Jacobi** (Mary P.): Syst. Pract. Med. [Pepper], iv. 1886, p. 557; *also* (Microscopical Studies in), Journ. Nerv. and Ment. Dis., xiv. 1887, p. 577. **Middleton**: Glasg. Med. Journ., xxii. 1884, p. 81; *Ibid.*, xxix. 1888, p. 526. **Nicholson** (In Four Brothers): Lancet, 1889, i. p. 1081. **Preisz** (Histological Examination): Arch. f. Psychiat., xx. 1888-89, p. 417. **Schultze**: Arch. f. path. Anat., xc. 1882, p. 208. **Suckling** (In Adult): Brit. Med. Journ., 1884, ii. p. 21.

SPASTIC PARALYSIS.

982. The lateral pyramidal tracts are sometimes the subject of a primary sclerosis. The condition is said to commence in a destruction of the nerve tubes, the fibrous overgrowth being superadded. The chief result of the defect is a paresis or weakening of the limbs, combined with spastic contraction of the muscles.

There are two varieties of the disease: (1) where the pyramidal tracts of the cord are alone affected; and (2) where along with the sclerosis of the pyramidal tracts there is more or less widespread destruction of the trophic ganglion cells in the anterior horn of gray matter. As a rule, the disease in both cases is symmetrical. To the former the name **primary lateral sclerosis** is usually given, to the latter that of **amyotrophic lateral sclerosis.**

Pure primary lateral sclerosis is a very rare disease; only a few cases are on record (see Dreschfeld, No. 5, xv. 1880-81, p. 510). The chief difference between the resulting phenomena of the two lesions is that, in the former, the nourishment of the muscles is retained, and the spastic contractions and paresis stand out as the most striking feature; while, in the latter, in addition to the spastic paresis, there is marked wasting of the muscles of the limbs.

The disease in both cases is easily diagnosed from locomotor ataxia. It must be borne in mind, however, as already mentioned, that sclerosis of the posterior columns is occasionally combined with a sclerosis of the crossed pyramidal tract, and that the resulting phenomena in this case are blended.

Literature on Spastic Paralysis.—**Bennett** (Spastic Paralysis): Lancet, 1886, i. p. 484. **Charcot**: Leçons sur les maladies du système nerveux, 1874, p. 218 *et seq.*; *also* (Two New Cases with P. M. Exam.), Arch. de Neurol., x. 1885, p. 168. **Collyns** (Amyotrophic): St. Barth. Hosp. Rep., xix. 1883, p. 343. **Coxwell** (Amyotrophic): Trans. Path. Soc. Lond., xxxv. 1883-84, p. 42. **Debove and Gombault** (Amyotrophic): Arch. de physiol. norm. et path., vi. 1879, p. 751. **Dreschfeld** (Primary

Lateral): Journ. Anat. and Physiol., xv. 1880-81, p. 510. **Erb** (Relationship to Tabes): Arch. f. Psychiat., vii. 1876, p. 238. **Ferrier** (Amyotrophic): Lancet, 1881, i. p. 822. **Fürstner:** Neurol. Centralbl., viii. 1889, p. 666. **Gombault:** Étude sur la sclérose latérale amyotrophique, 1877. **Ormerod:** Brain, ix. 1886-87, p. 245. **Risse** (Amyotrophic): Deut. Arch. f. klin. Med., xliv. 1888-89, p. 523. **Schmaus:** Deut. Arch. f. klin. Med., xlvi. 1889-90, p. 113. **Shaw:** Bristol Med.-Chir. Journ., ii. 1884, p. 270. **Stewart (G.)** (Spasmodic Paraplegia): Trans. Med.-Chir. Soc., Edin., viii. 1888, p. 189. **Strümpell** (Amyotrophic): Arch. f. Psychiat., xi. 1880, p. 32; *also* (Amyotrophic), Deut. Arch. f. klin. Med., xlii. 1887, p. 230. **Suckling:** Brit. Med. Journ., 1883, i. p. 252; *also* (Combined Dis. of Post.-Ext. and Lat. Tracts), Lancet, 1886, i. p. 59. **Westphal** (Amyotrophic): Arch. f. Psychiat., xvii. 1886, p. 279.

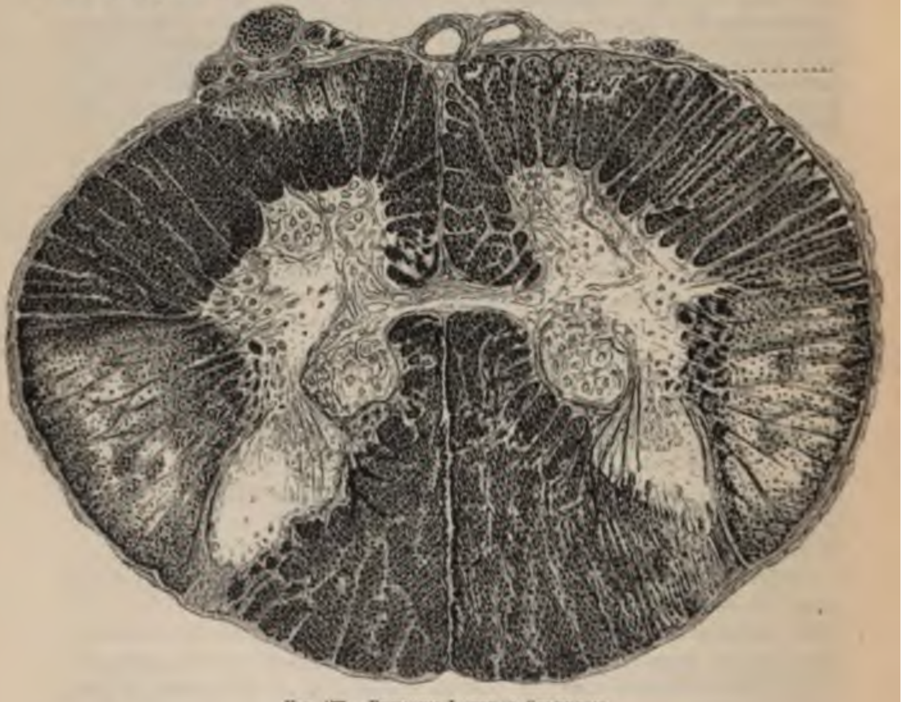


FIG. 477.—PRIMARY LATERAL SCLEROSIS.

The chief patches are located in the crossed pyramidal tracts. A small patch is also visible in each anterior column (× 50 Diams., reduced—Weigert's Hæmatoxylene Stain).

ACUTE ASCENDING PARALYSIS (*Landry's Paralysis*).

983. **Definition.**—This remarkable disease is particularised by *an ascending motor paralysis, by few abnormalities of sensation, and by immunity of the sphincters.* The disease may end fatally. It may also sometimes pass off without leaving any permanent ill effect.

Its pathology is still very obscure. The cord has been examined repeatedly, and although occasionally it has been found diseased, yet the changes in it have been of minor importance and inconstant.

They do not explain the paralysis. A notion now prevalent is that it is caused by a vegetable toxin secreted by a microphyte. The toxin may act upon the peripheral nerves or upon the cord itself.

Baumgarten (No. 126, 1876, referred to by Nauwerck and Barth) stated that the *bacillus of anthrax* was present throughout the body in one case, and that it was accompanied by a hyaline effusion round the vessels of the cord. Curschmann (also referred to by same) asserted that he had found the *typhoid bacillus* widespread throughout the body in another case. He was enabled to obtain a pure culture of the bacillus from the dorsal and cervical cord.

Literature on Acute Ascending Paralysis (*Landry's Paralysis*).—**Berardinone**: Riforma Med., Naples, v. 1889, pp. 729, 735. **Brown**: Brain, xiii. 1890-91, p. 375. **Buck**: Lancet, 1885, ii. p. 12. **Carter**: Brit. Med. Journ., 1890, i. p. 1127. **Clark**: Lancet, 1884, ii. p. 1089. **Dejerine**: Recherches sur les lésions, etc., dans la paralysie ascendante aiguë, 1879. **Dejerine and Goetz**: Arch. de physiol. norm. et path., iii. 1876, p. 312. **Hoffmann**: Arch. f. Psychiat., xv. 1884, p. 140. **Jacobi**: Berl. klin. Wochnschr., xxi. 1884, p. 311. **Kahler and Pick**: Arch. f. Psychiat., x. 1880, p. 313. **Klebs**: Deut. Med. Wochnschr., January 15, 1891. **Landry**: Traité complet des paralysies, 1859 (tome i.); *also*, Gaz. hebd. de méd., vi. 1859, pp. 472, 486. **Mann**: Med. Chron., Manchester, vi. 1887, p. 99. **Nauwerck and Barth** (Path. Anat.): Beitr. z. path. Anat., u. z. allg. Path., Ziegler, v. 1889, p. 1. **Pitres and Vaillard**: Arch. de physiol. norm. et path., ix. 1887, p. 149. **Schulz and Schultze**: Arch. f. Psychiat., xii. 1881, p. 457. **Schwartz**: Wien. med. Bl., x. 1887, p. 249. **Weber**: Journ. Nerv. and Ment. Dis., N. Y., x. 1885, p. 442. **Westphal**: Arch. f. Psychiat., vi. 1875-76, p. 765.

Reflex Paralysis.

984. **Definition.**—True reflex paralysis consists in *a more or less complete paralysis of motion, generally confined to one or both of the lower extremities, and caused by some peripheral irritation acting reflexly upon the spinal cord, or perhaps more especially upon its blood-vessels.*

Its Pathology. — The peripheral exciting causes are usually some affection of the skin, uterus, intestine, or bladder, and the most likely explanation of the occurrence of the paralysis is that a stimulus from these diseased organs is conveyed to the blood-vessels of the cord and causes a contraction of their channels, with consequent anæmia of the parts irrigated by them. Brown-Séquard stated that he saw the vessels of the spinal pia mater on one side contract when the kidney or supra-renal capsules were encircled by a ligature or otherwise irritated.

Urinary Paraplegia.

985. This is often mistaken for reflex paralysis, although the pathology of the two diseases seems to be distinct and unrelated. In the former, a lesion of the cord is never found, in the latter, such has been discovered in several instances.

Vital Phenomena.—The patient, who is almost always a male, is generally in middle life and has quite likely been suffering for some time from a chronic gonorrhœa or some other *purulent* affection of the urinary passages. The catheter is passed probably owing to some difficulty in micturition. Some time afterwards he begins to get weak in the lower extremities, his legs shake under him, and, at the same time, there is considerable constitutional disturbance. This paresis may afterwards amount to complete paralysis. It is confined, however, to the lower extremities. The disease very often ends fatally.

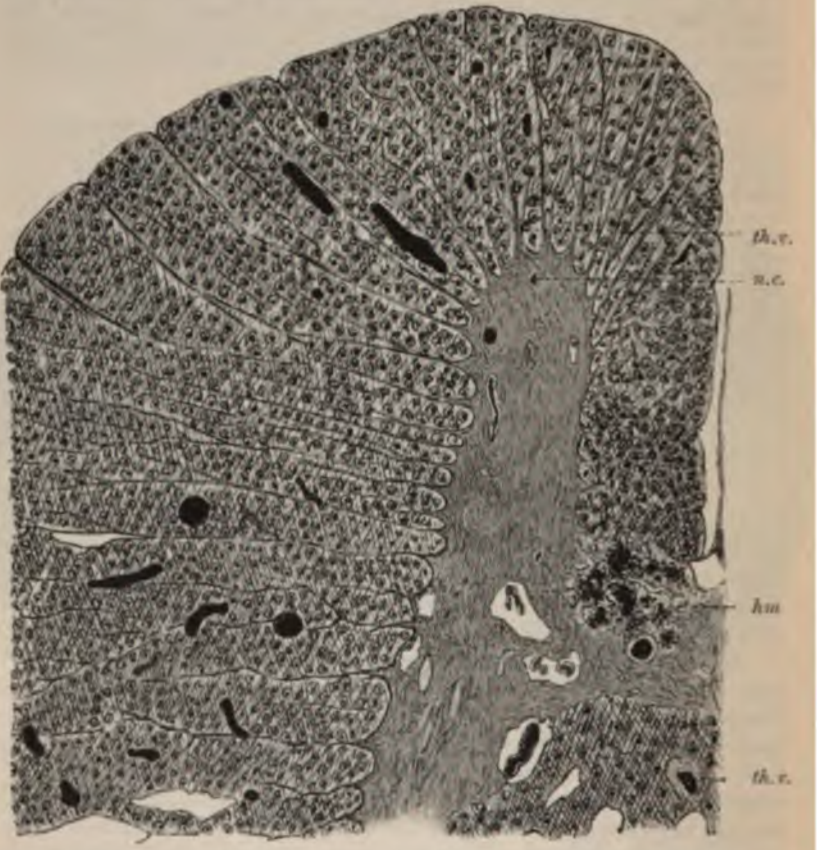


FIG. 478.—URINARY PARAPLEGIA. PART OF ANTERO-LATERAL COLUMN FROM LOWER DORSAL REGION (×40 DIAMS.)

(*th.v.*, *th.v.*) Thrombotic vessels ; (*n.c.*) nerve cell ; (*hm*) hæmorrhagic focus (Carmine and Clarified).

Its Pathology.—Gull (see Bibliog.) first demonstrated the true nature of the disease. In all the cases in which he obtained an autopsy he found that there was suppurative disorganisation of the cord. The suppuration appeared to have been propagated along the veins leading from the pelvis and which anastomose with the vertebral veins in the lower dorsal and lumbar regions. The vertebral veins in some instances were filled with pus.

A case supporting the above notion of the organic and probably septic nature of the disease was published by the author (No. 148, lvii. 1876, p. 440) a good many years ago. The autopsy revealed thrombosis of the veins of the cord, together with apoplexies and disorganisation of the cord itself (Fig. 478). The area of the cord affected was extensive, but the morbid appearance was most evident in the lumbar and lower dorsal regions.

Literature on Reflex Paralysis and Urinary Paraplegia.—**Annandale**: Edin. Med. Journ., xxiii. 1877-78, p. 847. **Bradley** (Urethral): N. Y. Med. Rec., x. 1875, p. 356. **Bristowe**: Brit. Med. Journ., 1872, i. p. 610. **Charcot**: Allg. Wien. med. Ztg., xvii. 1872, pp. 557, 574, 591. **Gull**: Med.-Chir. Trans., xxxix. 1855-56, p. 195; *also*, Guy's Hosp. Rep., vii. 1861, p. 313. **Hamilton**: Brit. and For. Med.-Chir. Rev., lvii. 1876, p. 440. **Jones**: Practitioner, xii. 1874, p. 170. **Leyden**: Sammlung klin. Vortr., 1870, No. 2 (Innere Med., No. 1), 1-22. **Mitchell, Moorehouse, and Keen**: Circular, No. 6, Surgeon-General's Office, Washington, 1864. **Nothnagel**: Arch. f. Psychiat., vi. 1875-76, p. 332. **Ogle**: Lancet, 1862, i. p. 315. **Pommer**: Zur Lehre v. d. Paraplegia urinaria, 1862. **Sayre**: Phila. Med. Times, xiii. 1882-83, p. 123. **Starr** (Reflex Neuroses): Med. News, Phila., lvi. 1890, p. 299. **Treub**: Arch. f. exper. Path. u. Pharmakol., x. 1878-79, p. 398. **Woodward** (Reflex Neuroses): Med. Rec., N. Y., xxxvii. 1890, p. 81.

CHOREA.

986. There is no denying the fact that, voluminous as the literature on the subject may be, we know practically nothing of the pathology of this disease. Embolism of the capillaries of the brain, thrombosis of cerebral and spinal blood-vessels, congestion and what not of those of the basal ganglia, together with softenings of the cord and swelling of its ganglion cells, have each done duty as a basis to found a pathology upon. It only requires to be said that all of them have been duly weighed and found wanting.

Literature on Chorea.—**Bastian**: Brit. Med. Journ., 1877, i. pp. 36, 65. **Broadbent**: Brit. Med. Journ., 1869, i. p. 345. **Dana** (Path. Anat.): Brain, xiii. 1890, p. 71. **Dickinson**: Med.-Chir. Trans., lix. 1876, p. 1. **Elischer** (Chorea Minor): Arch. f. path. Anat., lxi. 1874, p. 485. **Hanford**: Brain, xii. 1889, p. 129. **Hoffmann**: Arch. f. path. Anat., cxi. 1888, p. 513. **Huber** (Hereditary): Arch. f. path. Anat., cviii. 1887, p. 267. **H. Jackson** (Embolic Theory): Brit. Med. Journ., 1876, ii. p. 813. **Kirkes**: Lond. Med. Gaz., xi. 1850, p. 1004; *also*, Med. Times and Gaz., 1863, p. 677. **Mackenzie** (Embolic Theory): Brit. Med. Journ., 1876, ii. p. 814. **Tait** (In Pregnancy): Dub. Quart. Journ. Med. Sc., xlv. 1868, p. 203. **Wilks**: Med. Times and Gaz., 1869, i. p. 135.

SIMPLE AND MULTIPLE NEURITIS.

987. Inflammation of a single nerve or of several nerves supplying, say a limb, may be the result of injury or septic infection. When septic it usually has a suppurative tendency, and the pus spreads along the course of the nerve. In some forms of neuritis the lesion takes on a sclerotic character. New cicatricial tissue is

deposited between the nerve fibres, which in time contracts upon them and brings about their destruction. To all such cases the term **simple neuritis** is applied.

There exists a condition of the nerves, however, usually regarded as a neuritis, in which several nerves are simultaneously and, as a rule, symmetrically involved. The peripheral ends of the nerves, moreover, are more implicated than the parts which are more central. The terms **peripheral paralysis** or **multiple neuritis** are accordingly applied to it. The paralysis is not always complete; it may amount to nothing more than a paresis. The paralysis, moreover, spreads from below upwards and somewhat resembles that of acute ascending palsy. The various sensibilities will be found, however, to have deteriorated more or less, while in Landry's paralysis sensation is usually spared. In its commencement and progress the disease is markedly bilateral, and as a rule it is recovered from.

In cases where an examination of the nerves has been obtained their peripheral extremities have been found extensively diseased.

In a typical case published by Stewart (No. 19, xxvi. 1881, p. 865) the author examined the parts after death and found that the brain was quite sound, but that the peripheral extremities of the nerves leading to the hands and feet were profoundly altered. It was thought that in the cervical and lumbar enlargements the tracts of Goll and the ascending cerebellar tracts were perhaps a little more distinct than usual. There was not, however, any disintegration of the cord which could be regarded as primary.

Of all the nerve trunks affected, the median, ulnar, and tibial had suffered most. Looked at with a low power, on transverse section, certain bundles of fibres seemed to be totally, others only partially destroyed. In the ulnars the degeneration was less evident than in the medians. Indeed in the medians there was hardly a single intact bundle of fibres.

The degeneration commenced by a swelling and contraction of the axis-cylinder. The swollen portions then separated and subsequently underwent fatty degeneration. The destruction was at its extreme in the smallest subdivisions of the nerves; it ceased at a point immediately below the brachial plexus.

The most likely explanation of the recovery which so frequently takes place is probably that the continuity of the nerve up to its peripheral distribution is re-established by the axis-cylinders of the proximal end being pushed into the disused peripheral part of the sheath.

These cases are often without assignable cause. In some instances the neuritis appears to be the result of **chronic alcoholism.** The paralysis following **diphtheria** has already been described (p. 24) as owing to a peripheral nerve affection of the same kind; and that accompanying **lead** and **arsenical poisoning** seems to be due to the same cause. The disease known as **Kak-Ke** or **Beri-Beri** manifests itself chiefly as a peripheral neuritis.

Raynaud's Disease (Symmetrical Gangrene).

988. A peculiar disease now usually regarded as associated with a peripheral neuritis was described a good many years ago by Raynaud (see Bibliog.). It is characterised by the occurrence of patches of gangrene located with a peculiarly symmetrical distribution upon the extremities, neck, face, etc. The gangrene is so severe that the toes or fingers may slough off. It shows itself mostly in girls and is seldom fatal, even although the sloughs are extensive (Figs. 480, 481).

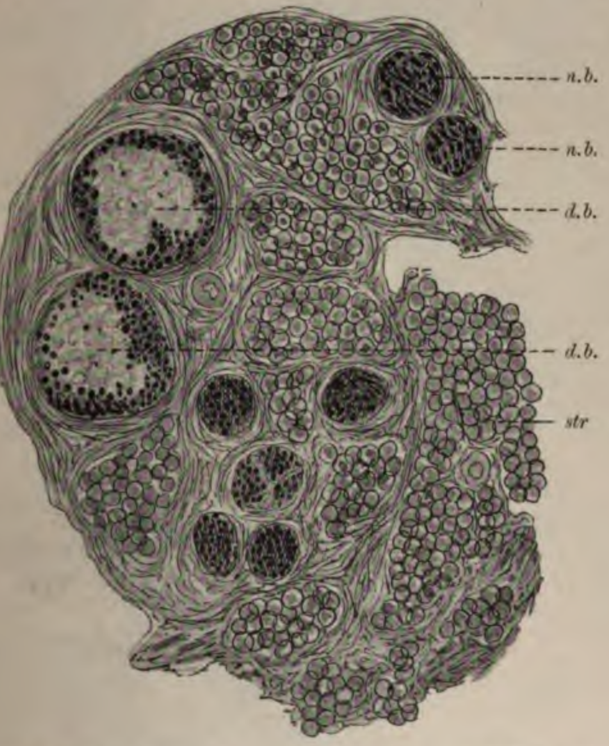


FIG. 479.—CROSS SECTION OF PART OF INTERNAL PLANTAR NERVE FROM A FOOT AMPUTATED FOR RAYNAUD'S DISEASE (×50 DIAMS.)

(*d.b.*, *d.b.*) Bundles of nerve fibres in which the nerve fibres have been partially destroyed by degeneration. The light parts are those which have degenerated. (*n.b.*, *n.b.*) Bundles of normal nerve fibres; (*str*) surrounding fibrous stroma with islands of fat (Weigert's Stain).

In cases where the nerves leading to the sloughing parts have been examined (see Affleck and Wiglesworth—Bibliog.) a lesion has generally been discovered. Thomson, who made the examination in

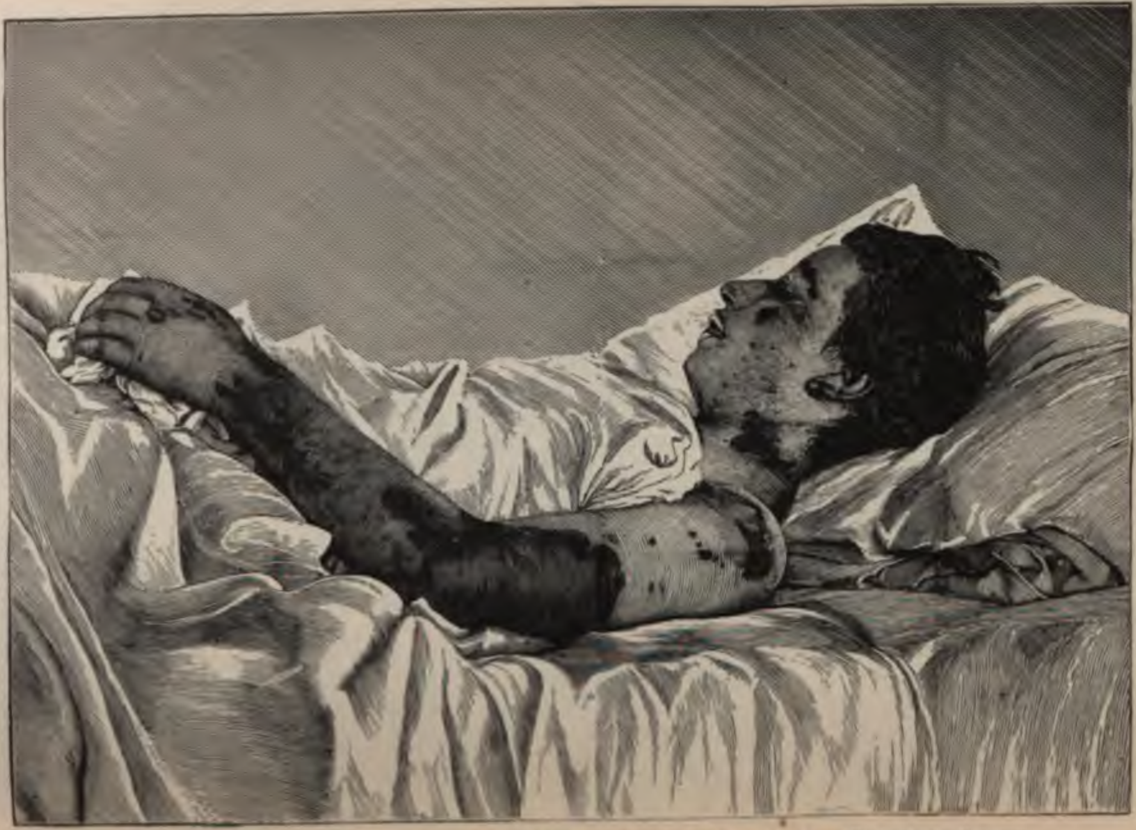


FIG. 460.—CASE OF RAYNAUD'S DISEASE IN A GIRL. LEFT SIDE OF THE BODY SHOWING THE GANGRENOUS PATCHES.

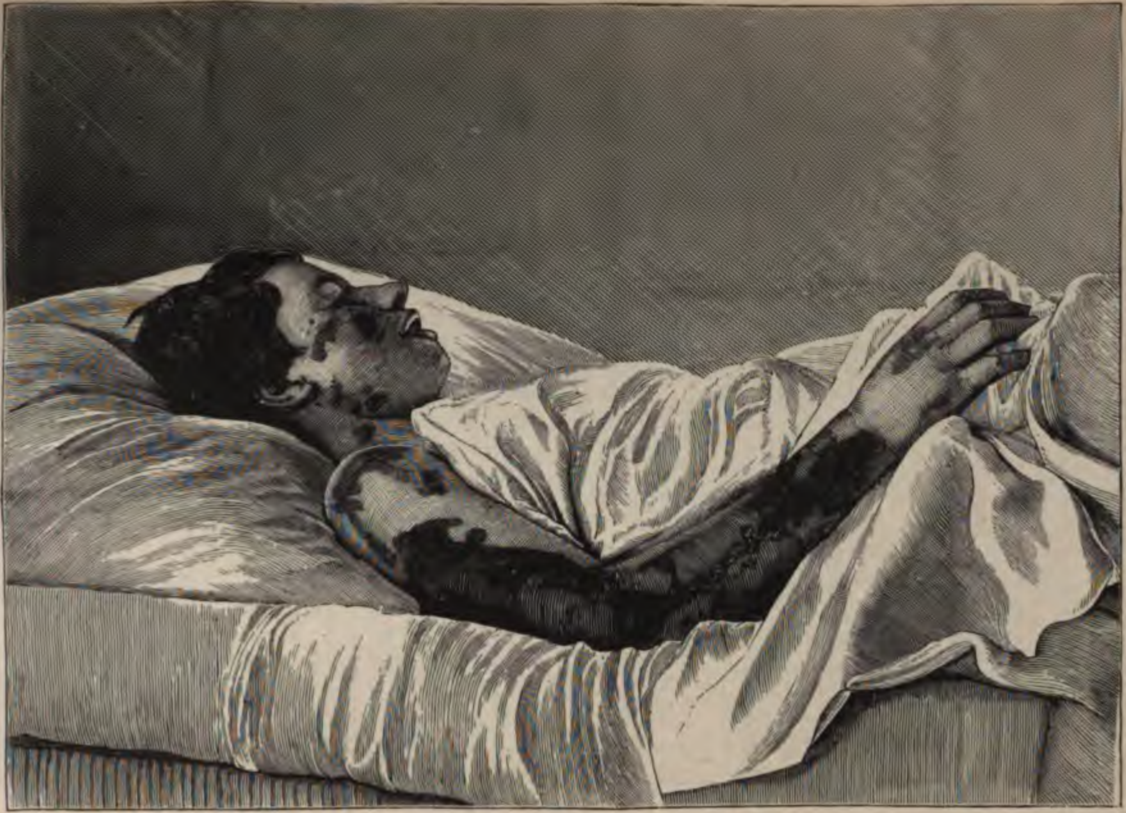


Fig. 481.—Raynaud's Disease. Same Case as that depicted in Fig. 480, showing the Symmetry of the Gangrenous Patches.

Affleck's case, found evidence of neuritis with subsequent fatty degeneration of many of the nerve bundles (Fig. 479). The disease of the nerve is supposed to influence the blood circulation locally, and thus to deprive the part of its proper nutrition ; hence the sloughs.

Literature on Diseases of Peripheral Nerves.—**Adamkiewicz** (Nerve Bodies in Diseased Nerves): Arch. f. Psychiat., xxi. 1889-90, p. 628. **Biggs:** N. Y. Med. Rec., xxxi. 1887, p. 503. **Buzzard:** Lancet, 1885, ii. pp. 983 *et seq.* **Dejerine:** Arch. de physiol. norm. et path., iii. 1884, p. 231. **Duckworth:** St. Barth. Hosp. Rep., xxii. 1886, p. 253. **Engelmann** (Degenerations of Nerve Fibres): Arch. f. d. ges. Physiol., xiii. 1876, p. 474. **Erb:** Cycl. Pract. Med. (Ziemssen), v. p. 11. **Eulan** (Multiple Neuritis); Berl. klin. Wochnschr., xxiii. 1886, p. 179. **Gessler** (Motor-End-Plate in): Arb. a. d. med.-klin. Inst. d. k. Ludwig. Maximilians-Univ. zu München, 1890, ii. p. 1. **Heller:** Specielle Path. u. Therap. d. Krankheiten d. periph. Nerven, 1879. **Hirt:** Neurol. Centralbl., iii. 1884, p. 481. **Kast:** Deut. Arch. f. klin. Med., xl. 1886-87, p. 41. **Leyden:** Deut. mil.-ärztl. Ztschr., xvii. 1888, p. 100. **Lilienfeld** (Multiple Neuritis): Berl. klin. Wochnschr., xxii. 1885, p. 727. **Masius and Francotte** (Multiple Neuritis): Bull. acad. roy. de méd. de Belgique, xx. 1886, p. 194. **Oppenheim** (Multiple Neuritis): Ztschr. f. klin. Med., xi. 1886, p. 232. **Oppolzer:** see Allg. Wien. med. Ztng. for 1860, 1861, and 1862. **Poincaré:** Le système péripherique, etc., 1877. **Rosenheim** (Acute Infect. Mult. Neuritis): Arch. f. Psychiat., xviii. 1887, p. 782. **Ross:** Brit. Med. Journ., 1887, i. p. 6 ; *also*, Med. Chronicle, Manchester, x. 1889, p. 265 *et seq.* ; xi. 1889-90, p. 1 *et seq.* ; xii. 1890, p. 91 *et seq.* **Senator** (Neuritis and Myositis): Ztschr. f. klin. Med., xv. 1888, H. 1 and 2 ; *also*, Reprint. **Starr:** N. Y. Med. Rec., xxxi. 1887, pp. 141, 173. **Stewart:** Edin. Med. Journ., 1881. **Stroebe** (Degeneration and Regeneration of Peripheral Nerves): Beitr. z. path. Anat. u. z. allg. Path., xiii. 1893, p. 160. **Strümpell:** Arch. f. Psychiat., xiv. 1883, p. 339. **White:** Trans. Path. Soc. Lond., xxxvii. 1886, p. 107. **Witkowski:** Arch. f. Psychiat., xviii. 1887, p. 809. **Wundt** (Nerves in Inflamed Organs): Arch. f. path. Anat., x. 1856, p. 404.

Literature on Raynaud's Disease.—**Affleck:** Brit. Med. Journ., 1888, ii. p. 1269. **Fox:** Lancet, 1885, i. p. 990. **Friedel:** Ein Fall v. symmetrischer Gangrän, 1889. **Raynaud:** Thesis, 1862 ; *also*, Arch. gén. de méd., 1874, i. p. 5 ; see *Eng. Transl.* of these, N. Syd. Soc., 1888. **Smith-Shand:** Brit. Med. Journ., 1888, i. p. 343. **Starr:** System of Practical Med. (Pepper). **Stevenson:** Lancet, 1890, ii. p. 917. **Thomas** (With Convulsions and Hæmoglobinuria): Johns Hopkins Hosp. Rep., Balt., ii. 1890, p. 114. **Wiglesworth** (Peripheral Neuritis in): Trans. Path. Soc. Lond., xxxviii. 1887, p. 61.

Literature on Tumours of the Brain.—**Bernhard:** Hirngeschwülste, 1881. **Bramwell** (Glioma): Edin. Med. Journ., xxxii. 1886-87, p. 616 ; *also*, Intracranial Tumours, 1888. **Buchholz** (Gliomata of Cerebral Cortex): Arch. f. Psychiat., xix, 1888, p. 591. **Bullen** (Multiple Sarcomata): Journ. Ment. Sc., Lond., xxxiii. 1887, p. 533. **Coats** (Adenoid Sarcoma with Cartilage of Pineal Gland): Trans. Path. Soc. Lond., xxxviii. 1887, p. 44. **Dalton** (Multiple Tubercular): Trans. Path. Soc. Lond., xl. 1888-89, p. 20. **Delbano:** Beiträge zur Symptomatologie u. Diagnostik d. Geschwülste d. Pons Varolii, 1891. **Edes** (T. of Thalamus and Int. Capsule): N. Y. Med. Rec., xxxvii. 1890, p. 578. **Finny** (Tub. T. of Pons): Tr. Roy. Acad. Med., Ireland, vii. 1889, p. 318. **Greves** (Endothelioma of d. Mater): Trans. Path. Soc. Lond., xxxviii. 1887, p. 20. **Griffith and Sheldon** (of Frontal Lobes): Journ. Ment. Sc., xxxvi. 1890, p. 223. **Hafner** (Tubercular): Berl. klin. Wochnschr., xxvi. 1889, p. 694. **Heusser** (Hypophysis Tumours): Arch. f. path. Anat., cx. 1887, p. 9. **Hippel** (Hypophysis with Synopsis of Lit.): Arch. f. path. Anat., cxxvi. 1891, p. 124. **Hitzig** (Hypertrophy): Cycl. Pract. Med. (Ziemssen), xii. 1877, p. 823. **Hun** (Gliomatous Hypert. of Pons): Med. News, Phila., li. 1887, p. 386. **Kaiser:** Ueb. d. Psammome au d. Dura Mater, 1886. **Ladame:** Hirngeschwülste, 1865. **Leslie and Bramwell** (T. of Cerebellum): Edin. Med. Journ., xxxii. 1886-87, p. 591. **Macgregor** (Pons): Lancet, 1886, ii. p. 1127 ; *also* (of Pons), Lancet, 1889, i. p. 1079. **Mott** (Myxo-Fibroma): Trans. Path. Soc. Lond., xxxviii. 1887, p. 52. **Nothnagel** (Tumours in Region of Corp. Quad.): Journ. Nerv. and Ment. Dis., N. Y., xvii. 1890, p. 248, *Transl.* ; Brain, xii. 1889, p. 21.

Noyes and Dana (of 4th Ventricle): N. Y. Med. Rec., xxxviii. 1890, p. 94. **Oppenheim:** Arch. f. Psychiat., xxi. 1889-90, pp. 560, 705; xxii. 1890, p. 27. **Osler** (Cholesteatoma of 3rd Vent.): Journ. Nerv. and Ment. Dis., N. Y., xiv. 1887, p. 657. **Otto** (Hyperplasia of Brain in form of small Cortical Tumours): Arch. f. path. Anat., cx. 1887, p. 81. **Pilhet** (Endothelioma of D. Mater): Bull. Soc. Anat. de Par., lxiv. 1889, p. 189. **Price** (Cholesteatomata at Base): Trans. Path. Soc. Lond., xxxviii. 1887, p. 24. **Schultze** (Gliosis of Sp. Cord): Arch. f. path. Anat., cii. 1885, p. 435. **Steven** (Multiple Tubercular): Brit. Med. Journ., 1890, i. p. 1244. **Taubner** (Brain Lipoma): Arch. f. path. Anat., cx. 1887, p. 95. **Thompson** (Three Cases of, in Frontal Lobe): Med. News, Phila., lvi. 1890, p. 586. **Toche:** Étude sur deux cas d'endothéliome du cervelet, 1888. **Tuke** (Hypertrophy): Journ. Anat. and Physiol., vii. 1873, p. 257. **Weber** (Hydatid Cyst on Left Hemisphero): Trans. Path. Soc. Lond., xl. 1888-89, p. 17.

Literature on Recent Technique of Nervous System.—**Beevor** (Staining Nerv. Syst. *in toto*): Brain, viii. 1885-86, p. 239. **Blackburn** (Method of Preparing Brain): Trans. Internat. Med. Cong., ix., Wash., 1887, iii. p. 407; *also*, Journ. Nerv. and Ment. Dis., N. Y., xvi. 1889, p. 113. **Bramwell** (Method of Preparing Large Sections of Brain): Brain, x. 1887-88, p. 435. **Dogiel** (Impregnation with Methylene Blue): Arch. f. mik. Anat., xxxiii. 1889, p. 440. **Feist** (Vital Methylene Blue Staining): Arch. f. Anat. u. Entwickelungs-gesch., 1890, p. 116. **Flechsig** (New Staining Method): Arch. f. Physiol., 1889, p. 537. **Freud** (New Method of studying Course of Nerve Fibres): *Transl.*, Brain, vii. 1884, p. 86. **Friedmann** (New Modification of Weigert's Staining Process): Neurol. Centralbl., iv. 1885, p. 135. **van Gieson** (Résumé): Journ. Nerv. and Ment. Dis., N. Y., xiv. 1887, p. 351. **Gray** (Modification of Weigert's Method of Staining): Med. News, Phila., xlix. 1886, p. 515. **Greppin** (Golgi's Method of Staining): Arch. f. Psychiat., xx. 1888, p. 222; *also* (Golgi's Method), Arch. f. Anat. u. Entwicklngs-gesch., Suppl. Bd., 1889, p. 55. **Kowalewsky** (Vital Action of Methylene Blue): Centralbl. f. d. med. Wissensch., xxvi. 1888, p. 209. **Lewis:** Quart. Journ. Mic. Sc. xvi. 1876, p. 69; *also*, Med. Times and Gaz., i. 1876, p. 247; *also*, Brain, i. 1878, p. 79; *also*, *Ibid.*, p. 348. **Marchi** (Demonstration of Fibres affected with Secondary Degeneration): Rivista sperimentali di Fremiatria et de medicina legale, 1887, p. 208. **Merkel** (New Method of Research): Arch. f. mik. Anat., xiv. 1877, p. 621. **Minor** (Rapid Hardening of Sp. Cord by Electricity): Neurol. Centralbl., ix. 1890, p. 294. **Pal** (Staining of Nerve Tissue): Med. Jahrb. Wien., 1886, i. p. 619; *also*, *Ibid.*, 1887, ii. p. 159. **Redfern** (Pal-Exner Method): Brit. Med. Journ., 1888, i. p. 642. **Rosenbach** (A Simple Method of Hardening Brain): Centralbl. f. Nervenh., xii. 1889, p. 164. **Sahli** (Borax-Methylene Blue as Staining Reagent): Ztschr. f. Wissensch. Mikr., ii. 1885, p. 49. **Sankey:** Quart. Journ. Mic. Sc., xvi. 1876, p. 182. **Starr** (Methods of Staining): Journ. Nerv. and Ment. Dis., x. 1885, p. 143. **Weigert** (New Method of Investigation): Centralbl. f. d. med. Wissensch., xx. 1882, pp. 753, 772. **Welcker** (Two Aids to Demonstration): Arch. f. path. Anat., lxxiv. 1878, p. 500. **Wilson:** Brooklyn Med. Journ., iv. 1890, p. 224.

General Literature on Pathology of the Nervous System—Text-Books, etc.

André: Les nouvelles maladies nerveuses, 1892. **Arnold** (Combined Diseases of the Tracts of the Cord): Arch. f. path. Anat., cxxvii. 1892, p. 18. **Babés and Blocq:** Atlas der path. Histologie des Nervensystems, 1 Lief, 1892. **Barr** (Hæmorrhage into Pons): Lancet, 1890, i. p. 751. **Bastian:** Paralysis, cerebral, bulbar, spinal, etc., 1886. **Bramwell** (Apoplexy): Edin. Med. Journ., xxxii. 1886-87, p. 243; *also*, Diseases of Sp. Cord, 1886. **Brown-Séquard** (Lectures): Lancet, 1858, ii. p. 1 *et seq.* **Bruns** (Pons Tubercle): Neurol. Centralbl., v. 1886, pp. 151, 169. **Bruttan:** Ein Beitrag z. Casuistik d. centralen Gliose, etc., 1892. **Buzzard:** Diseases of the Nervous System, 1882; *also* (Multiple Paralysis of Cranial Nerves), Brain, xi. 1888-89, p. 84. **Campbell and Turner** (Heterotopia of Spinal Cord): Trans. Path. Soc. Lond., xlii. 1890, p. 20. **Charcot:** Clinical Lectures, Diseases of the Nervous System, N. Syd. Soc., 1877-83; *also*, Œuvres complètes, 1887. **Collier** (Cerebral Hæmorrhage in Children): Brit. Med. Journ., 1889, ii. p. 719. **Critzman:** Essai sur syringomyélie, 1892. **Dagonet** (Cylindroma of Dura Mater): Arch.

de méd. exper. et de l'anat. path., iv. 1892, p. 361. **Dana:** Text-Book of Nervous Diseases, 1892. **Dreschfeld** (Muscular Atrophies): Brain, viii. 1885-86, p. 164. **Drummond:** Diseases of Brain and Spinal Cord, 1883. **Erb:** Cyclopædia of Pract. Med. (Ziemssen), xiii. **Erlicki and Rybalkin** (Combined System Diseases): Arch. f. Psychiat., xvii. 1886, p. 693. **Eulenburg:** Lehrbuch d. Nervenkrankheiten, 1878. **Ferrier:** Localisation of Cerebral Disease, 1886. **Galloway** (Syringomyelus): Trans. Path. Soc. Lond., xlii. 1890-91, p. 26. **Geigel** (Circulation within Brain and its Disturbances): Arch. f. path. Anat., cxix. 1890, p. 93; *Ibid.*, cxxi. 1890, p. 432; *Ibid.*, cxxv. 1891, p. 92. **Goldstein** (Anatomy, Physiology, etc., of Cortex): Schmidt's Jahrb., ccxi. 1886, p. 73. **Gowers:** A Manual of Diseases of the Nervous System, 1892; *also*, Lectures on Diagnosis of Diseases of the Brain, 1887. **Gray:** A Treatise on Nervous and Mental Diseases, 1892. **Hammond:** A Treatise on Diseases of Nerv. Syst., 1886. **Henschen:** Path. d. Gehirns, 1892. **Herzen and Loewenthal** (Three Cases of Lesion at Junction of Med. Ob. and Sp. Cord): Arch. de physiol. norm. et path., vii. 1886, p. 260. **Hückle:** Lehrbuch d. Krankheiten d. Nervensystems, 1891. **Jackson** (Comparative Study of Diseases of Nervous System): Brit. Med. Journ., 1889, ii. p. 355. **Kahler and Pick** (Combined System Diseases): Arch. f. Psychiat., viii. 1877-78, p. 251; ix. 1878-79, p. 413; x. 1879-80, pp. 179, 297. **Lewis:** A Text-Book of Mental Diseases. **Löwenfeld** (Cause and Path. of Cerebral Hæmorrhage): Arb. a. d. path. Inst. zu München, 1886, p. 310. **Lunz** (Affections of N. S. after Infect. Dis.): Arch. f. Psychiat., xviii. 1887, p. 882. **Macpherson** (Vacuolation of Nerve Cells): Lancet, 1892, i. p. 1127. **Magnan:** Recherches sur les centres nerveux, 1876. **Marie and Sousa Leite:** Essays on Acromegaly, *Eng. Transl.* N. Syd. Soc., 1891. **Martius** (Erb's Paralysis): Berl. klin. Wochnschr., xxiii. 1886, p. 453. **Mitchell:** Lectures on Diseases of Nerv. System, 1885. **O'Carroll** (Hydromyelus): Trans. R. Acad. Med., Ireland, ix. 1890, p. 411. **Ormerod:** Diseases of the Nervous System, 1892. **Oustaniol:** Contribution à l'étude des tumeurs des méninges rachidiennes, 1892. **Pitt** (Gulstonian Lectures on Cerebral Lesions): Brit. Med. Journ., 1890, i. p. 643 *et seq.* **Raymond:** Anat. path. du système nerveux, 1886. **Rosenthal:** Clin. Treatise on Dis. of Nerv. Syst. (*Eng. Transl.*), 1879. **Ross:** A Treatise on Dis. of Nerv. Syst., 1881; *also*, Handbook of Dis. of Nerv. Syst., 1885. **Rumpf:** Arch. f. Psychiat., xvi. 1885, p. 410. **Seeligmüller:** Lehrbuch d. Krankheiten des Rückenmarks u. Gehirns, etc., 1886. **Spitzka** (Anæmia and Hyperæmia): Syst. Pract. Med. [Pepper], v. 1886, p. 763. **Stewart:** Introduction to Dis. of Nerv. Syst., 1884. **Strümpell:** Lehrbuch d. spec. Path. u. Therap., 2 Bd., 1 Th., Krankheiten des Nervensystems. **Tooth** (Heterotopia of Gray Matter of Spinal Cord): Trans. Path. Soc. Lond., xlii. 1890, p. 14. **Vulpian:** Maladies du système nerveux, 1879. **White** (Corp. Striat. and Opt. Thal. and Body Temperature): Brit. Med. Journ., 1889, i. p. 1401; *also* (Path. Value of Gasserian, Lenticular, Spinal, and Cardiac Ganglia), Brain, xiii. 1890, p. 341. **Wilks:** Lectures on Dis. of the Nerv. Syst., 1878; *also*, Med. Times and Gaz., 1868, i. p. 1 *et seq.*

CHAPTER LXXXVI

THE THYROID GLAND, SUPRA-RENAL CAPSULES, AND SPLEEN

THYROID GLAND.

989. THE thyroid, like the supra-renal capsules, the pituitary body, and some other allied structures, is unprovided with a duct. Originally this does not seem to have been the case. The central lobe appears to have been furnished with a duct, which opened on the dorsum of the tongue at the foramen cæcum. The lateral lobes are developed from one (the fourth) of the branchial clefts (Steida, No. 608), and may be regarded as having been primitively racemose diverticula of the pharynx, with alveolar terminal pouches. No doubt their function was that of mucus-secreting organs. All trace of the thyro-glossal duct has usually vanished in Man, although now and again it remains persistent. The middle lobe has dwindled down into the isthmus and the occasional pyramidal lobe. The alveoli of the lateral lobes have become shut sacs, the thyroid vesicles. These vesicles still retain their glandular character in the fact that they are lined with epithelium and secrete an albuminous colloid substance. The secretion, however, is no longer poured into the pharynx, as it was originally, but is removed by the lymphatics of the organ and those surrounding it. If the gland be squeezed the secretion can be forced into these.

Its functions for long remained a mystery. It used to be classed among the blood-forming glands.

That it takes any part in regenerating blood corpuscles may be doubted. Horsley (No. 6, 1885, i. p. 211) adheres to the view that it does. He supposes the gland to consist of two elements, the one glandular and secreting a mucoid substance within highly vascular acini, the other made up of vascular lymphoid nodules having a hæmatogenous function. He founds the notion of its being a hæmatogenous gland upon the fact that when excised in animals decrease in the number of coloured and increase in that of the colourless corpuscles takes place.

This much may be said at the present day regarding its functions, namely, that from being supposed to be comparatively inert it has grown to be considered as of the greatest importance in the maintenance of health. It receives an abundant blood-supply, a fact which goes to strengthen this view.

The period of greatest functional activity of the thyroid, as with the supra-renals, is in youth. It is secreting before birth, and continues active until the vital processes generally begin to decay. Its artificial removal is attended by much more serious consequences in early youth than in adult age.

Effect of Removal of the Thyroid in the lower Animals and in Man.

Numerous experiments made upon the Continent, and more particularly those of Schiff (No. 104, xviii. 1884, p. 25), had proved some years ago that *removal of the gland in animals* induces a peculiar train of nervous and other symptoms known as the **cachexia strumipriva** or **thyroidectomica,** and characterised by mental hebetude, general nervous disturbance, tremors, paroxysmal convulsions, functional paralysis, and finally complete imbecility. Horsley (No. 6, 1885, i. p. 211) has repeated these experiments in this country, and, in addition to verifying what was alleged to occur, has demonstrated that, when the thyroid is excised in monkeys, an accumulation of mucin takes place in the blood and in those tissues which normally contain it; that great activity is noticed in mucin-secreting glands; and that the mucin-secreting power of the parotid under these circumstances becomes augmented.

The blood also suffers profound changes. These, as summarised by Horsley (No. 6, 1892, i. p. 216), are as follows: (*a*) increased venosity; (*b*) great diminution in the amount of contained oxygen, which in the arterial blood may fall below the normal proportion in the veins; (*c*) the presence of abnormal constituents, and more particularly mucin in the plasma.

Respiration, as might be expected from the state of the blood, is laboured. This is most likely caused by the depression of the respiratory centre, owing to the general lowering of metabolism, as well as to the direct toxic influence of the altered blood.

All flesh-eating animals are subject to the cachexia, but the monkey and Man more than any others.

Removal of the thyroid in Man has been so often resorted to of late in cases of goitrous or other disease, that its effects are well known. When the removal is complete they seem to correspond closely with what has been noted in animals. Reverdin of Geneva and Kocher of Berne (No. 92, xxix. 1883, p. 254) have recorded many cases of this kind, and in this country a very good description of the usual phenomena which follow the operation has been given by Gordon and

Stokes (see Bibliog.). Without going into details, suffice it to say that they closely resemble those of myxœdema (*q.v.*).

It has been attempted (Fuhr, No. 104, xxi. 1886, p. 387, and others) to explain the mental peculiarities following excision of the gland on the supposition that the operation also necessitates the removal of the apparatus (nerves) for the regulation of the blood pressure in the brain. This theory has been utterly disproved by later experience. The close resemblance between the phenomena following excision of the gland and those characteristic of myxœdema seems to point to the thyroid as having the power of removing or destroying mucin and other products of metabolism which, if not thus disposed of, tend to accumulate in different parts of the body, and to act injuriously upon it. There are two theories as to how this is accomplished: either that the gland discharges something into the circulation which is necessary for the maintenance of a proper composition of the blood; or that its secretion prevents autointoxication by transforming the poisonous products of tissue-change into those which are harmless and easily eliminated, or by neutralising them.

That the gland acts by destroying products of metabolism seems all the more likely from the fact that when, previous to the removal of the thyroid, a piece of thyroid from another animal is *artificially transplanted* into the subcutaneous tissues, or into the peritoneal cavity, the mal-effects of removal of the gland, as shown originally by Schiff, are warded off or greatly ameliorated. The piece of gland, if carefully transplanted, becomes vascularised, and if it dies and is absorbed no benefit is experienced. Very much the same influence is exerted by the piece of transplanted thyroid as follows upon transplantation of a piece of pancreas in an animal suffering from diabetes the result of excision of the pancreas (Sect. 878).

MYXŒDEMA.

990. **Historical.**—At a meeting of the Clinical Society of London the late Sir W. Gull (No. 293, vii. 1879, p. 180) described two cases of what he named "a cretinoid state supervening in adult life in women." The narration of these cases recalled to memory others which had come under the observation of those present, but whose nature had not been recognised. Ord (No. 293, xiii. 1880, p. 17) subsequently gave the disease the name "Myxœdema," and showed that the "mucin-yielding interstitial element" throughout the body was everywhere in excess. Since then the disease has been universally recognised.

General Phenomena.—A large proportion of cases occur in the female sex; the disease, however, has also been observed in the male. It is rarely that it becomes manifest before adult life has been reached; sometimes, however, it shows in infancy or early childhood. Up to the time of advent of the symptoms nothing peculiar mentally is noticed. On the contrary, some of those attacked have been bright and intelligent. The first sign of the affection is usually a swelling of the face, more particularly of the eyelids, a swelling which is frequently mistaken for dropsy from kidney disease. The swelling, however, does not pit on pressure. So great does it become that a previously well-visaged woman may become a somewhat hideous object to look upon. The skin also loses its natural lustre and becomes more or less waxlike; it may be dry and scurfy or loose and wrinkled. A bright rose spot is often seen on each cheek.

The subcutaneous swelling also affects other parts of the body. Thus under the chin and on the hands there is the same œdema-like appearance, although in these regions, as in the face, the swollen part does not pit on pressure. Gull described the hand as assuming a "spade-like" appearance. The fingers become thickened and the skin at the same time harsh and dry. The extremities often show signs of congestion and are blue and cold. The tongue may be so swollen as to protrude to the half of its extent from the mouth even after death.

With the advent of the subcutaneous swelling certain nervous phenomena supervene. The individual becomes dull, listless, unconcerned; the expression is placid; there are signs of great mental hebetude; and the speech assumes a peculiarly slow, monotonous, and deliberate character, with a certain amount of blurring, as if the individual held something in the mouth. Hearing and smell may be impaired, and the individual be drowsy or inclined to sleep. Symptoms of imbecility show themselves later on. It should be noted, however, that the nervous phenomena are sometimes ill marked or absent.

The hair tends to fall off, specially along the middle partition of the head, and from the axillæ, sometimes also from the pubes. The denuded scalp assumes a blanched scaly appearance, or an actual eczematous eruption may be found upon it.

On cutting into the tumid parts they are seen to be occupied by subcutaneous fat, which has a peculiarly bright yellow colour and gelatinous appearance, resembling that of the subcutaneous fat tissue in the young fœtus. The skin itself, so far as one can judge with the naked eye, does not seem much altered. The thickening does not affect it. The body, generally, shows a considerable quantity of fat tissue, but otherwise is often poorly nourished.

After death **the tongue** may be found to be double its natural size. The muscle has the grayish-brown anæmic aspect of the adductor muscles of the thigh, or of the flat muscles of the abdomen in typhoid fever. The fibres have also a glistening appearance, as if infiltrated with some gelatinous substance.

Small mucous cysts are occasionally met with upon the mucous membranes of the cervix uteri and bladder. The mucous membrane of the stomach may be thickened and have the same glassy appearance as the other parts affected.

The supra-renal capsules may be particularly small and shrunken. On cutting into them the whole interior will probably be found softened, and the gland, as in the case of the thyroid, entirely destroyed. Nothing perhaps remains but the capsule and a little pultaceous material of a brownish-red colour.

Ord (*loc. cit.*) states that he found a massive thickening of the coats of the arteries, more especially of the tunica adventitia, in the organs and tissues of the body generally. The nuclei of the adventitia were increased in number, and there was said to be a diminution in the size of the channel of the vessel. Everywhere the connective tissues approached in appearance the mucin-yielding umbilical cord. The difficulty in regulating the muscles for combined movements so often noticed, he believes, is probably caused by the excess of mucoid tissue lying around them.

The thyroid, in nearly all advanced cases, has been found wasted, so wasted as to be almost unrecognisable. In one instance of the disease examined by the author nothing but the capsule and interstitial stroma seemed to have been left. Sometimes it has been the seat of a new growth. Still it should be remembered that instances of almost complete destruction of the gland have been recorded without symptoms of myxœdema (see Hale White, No. 6, 1888, i. p. 587). Collateral circumstances, such as the presence of accessory thyroids, may perhaps account for this.

The Committee appointed by the Clinical Society of London (No. 293, suppl. vol. 1888) reported as the result of the microscopic examination of the gland that a delicate fibrous tissue invades it and replaces the gland tissue proper. The condition commences in a small-cell infiltration of the walls of the vesicles, and this is soon followed by proliferation in the vesicles themselves. The vesicles in time vanish or are represented by clumps of small round cells, while the fibrous tissue increases in quantity.

Treatment by Transplantation and by supplying Thyroid Secretion.—The most remarkable circumstance connected with this disease is the fact discovered of late that it can be ameliorated or eradicated by supplying the secretion of the thyroid gland artificially. The possibility of such a thing was suggested by Schiff's discovery, previously alluded to (p. 771), that the disastrous effects following removal of the thyroid in animals can be warded off by the transplantation of a piece of the gland from a fresh host.

Pieces of the gland from the sheep (see Gibson's case, No. 6, i. 1893, p. 58) have been transplanted into the subcutaneous areolar tissues, or have been stitched into the wall of the peritoneum, with the result that they have taken root and lived. In course of time a marked amelioration of the symptoms, if not a perfect recovery from the disease, ensued.

More lately, however, it has been found that the subcutaneous injection of a glycerine extract of the thyroid of the sheep has very much the same beneficial effect.

The extract, according to Murray's receipt (No. 6, 1891, ii. p. 797), is made in the following manner:—

> "The lobe of the thyroid gland of a sheep is removed as soon as possible after the animal has been killed. The surrounding fat and connective tissue are removed from it. All the instruments and glass vessels used in the further preparation of the extract should be either sterilised by heat or thoroughly cleansed with a 1 to 20 solution of carbolic acid. The gland is cut up on a glass dish into small pieces, and then placed in a test tube with 1 cubic centimètre of pure glycerine and 1 cubic centimètre of a 0·5 per cent solution of carbolic acid. The mouth of the tube is closed with a plug of cotton wool, and the mixture allowed to stand in a cool place for twenty-four hours. The mixture is then placed in a fine handkerchief which has previously been placed for a few minutes in boiling water. It is then firmly squeezed by screwing up the handkerchief so as to express as much liquid as possible through the handkerchief. By this means 3 cubic centimètres (50 minims) of a turbid pink liquid are obtained. This preparation, which will keep quite fresh for at least a week, should be kept in a small bottle with a glass stopper. It is best to make the extract fresh each week, so as to avoid any risk of putrefaction taking place. This extract may be given in two equal injections of 1·5 cubic centimètre (25 minims) each during the week, so that at first the patient receives the extract of one lobe of a sheep's thyroid in the course of each week. After a time the injections need not be made so frequently. The injections are made with an ordinary hypodermic syringe, which is carefully washed out with a 1 to 20 solution of carbolic acid both before and after the injection is made. The loose skin of the back, between the shoulder-blades, is a convenient situation in which to make the injection."

Not only may the extract be introduced into the system by subcutaneous injection, but it appears to be also efficacious when exhibited *per os.* A favourable result follows, although not with such certainty, when the thyroid, partially cooked, is used as food, or when it is administered in the form of powder.

The improvement begins to show itself soon after the treatment is commenced, at first by a diminution of the cellular tissue swelling, and later on by an improvement in the intelligence and general mental calibre of the person. A fresh crop of hair shows itself on the scalp; menstruation, which usually ceases during the progress of the disease, returns; and the general welfare of the patient improves so much that in many cases a perfect recovery may be said to have been obtained. In other cases, although recovery may not have been complete, so much improvement has taken place that the individual has been enabled to go about unguarded and to follow some avocation.

ACROMEGALY.

991. The disease "Acromegaly" (Marie, No. 521, xii. 1890, p. 59) bears a certain resemblance in many of its phenomena to myxœdema, but apparently differs from it in the preservation of the thyroid gland and in the absence of the mucoid infiltration of the tissues. It is, however, frequently mistaken for myxœdema. The hands and

feet are of huge dimensions; the nose and lower lip are similarly enlarged; the tongue is very large, long, and dense; and the neck is thick-set and short.

The most notable positive phenomenon is *the great size of the hands and feet.* This is acquired not congenital in its origin. The mental functions are often well preserved. There is an absence of that mental hebetude so characteristic of myxœdema. The patient later on falls into a condition of progressive cachexia, which requires his confinement to bed. Another point by which the disease can be diagnosed from myxœdema is that the bones of the extremities, and also to a certain extent those of the skull, in this disease are enlarged. There is likewise an absence of the "full-moon face" of myxœdema, the face as a rule being somewhat long and elliptic in form.

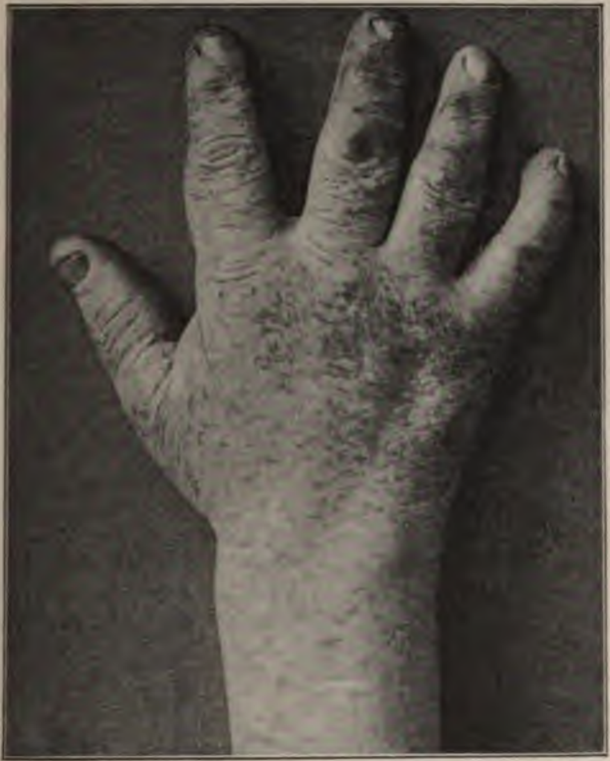


FIG. 482.—HAND OF A PERSON AFFECTED WITH ACROMEGALY.

In all the cases in which an autopsy has been obtained enlargement of the pituitary body has been found, sometimes with persistence of the thymus gland.

ENDEMIC GOITRE, BRONCHOCELE, OR STRUMA.

992. **Definition of Terms.**—These terms are used to designate an enlargement of the thyroid gland which occurs endemically in certain districts. The term *Goitre* is probably a corruption of the word "guttur," the throat; while that of *Struma*, although generally applied to a scrofulous enlargement of the lymph-glands, has also been employed to designate a goitrous enlargement of the thyroid.

Distribution.—It is not now an affection which is met with endemically to any extent in this country, but sporadic cases from time to time show themselves. The Derbyshire hills constituted a district in which formerly the disease was common, the swelling of the thyroid being known as the "Derbyshire neck." It is still, however, markedly endemic in the mountainous parts of Silesia, Bohemia, the Harz, Thuringia, and in the Swiss Alps. The valleys in Switzerland and the Austrian Alps are said to be free from it. It is also met with in the Himalayan mountains and the hilly parts of the Brazils.

Appearance of Gland.—It may weigh several pounds and become so enlarged as to prove cumbersome. The whole gland, one lobe, or the isthmus may be the seat of the swelling. In the last case the swollen part hangs down as a pendulous tumour.

On section, so far as naked-eye examination goes, the texture of the gland may not be much altered. Sometimes there are cysts within it filled with mucoid, ropy liquid. In certain parts fatty degeneration, calcification, or hæmorrhage may have occurred.

Microscopic examination reveals the fact that the tumour is composed of structures very much like those of health. Indeed the new growth seems to be an **adenomatous condition** of the organ. The vesicles are usually smaller than those of health and much more numerous. The new vesicles are pushed out from the old, as in many other adenomata. The quantity of colloid contained in them as a rule is less than in many healthy glands, although sometimes one or more become distended with it to form cyst-like collections.

Cause.—Very little is known of the cause of its occurring endemically. Removal from the district prevents it.

Supernumerary Goitrous Thyroid.—Accessory thyroid glands are occasionally met with. They may become so large as to necessitate removal. They sometimes lie in the middle line instead of laterally, or may be located in the upper part of the thorax.

CRETINISM [*Cretina*, a miserable creature (?)].

993. The cretinous constitution shows itself usually in endemic goitrous districts, but it is to be borne in mind that cretins, although in a large proportion of instances goitrous, are not always so. The districts in which it is commonest are the Swiss mountains and the Pyrenees.

It is characterised by feebleness of intellect or actual idiocy, accompanied by certain bodily malformations, chiefly the following:—The head is large and misshapen, being expanded at the sides and flattened at the vertex, and presenting therefore a strongly brachycephalic type. The cheek-bones are high and prominent; the nose flattened or sunken, broad at the root, and upturned. The interorbital space is widened, the lips thick, the mouth wide and held open, the tongue large. The individual is of stunted growth, with tumid belly and coarse skin. He suffers from great muscular weakness and the sexual functions are feeble or annulled. The mental phenomena are those of dulness of intellect, blunting of the senses, dementia, or complete idiocy.

Pathology.—The pathology of this disease, like that of its frequent associate endemic goitre, has proved a complete mystery. According to Virchow, cretins are born with the cartilages at the base of the skull ossified, a condition said to be caused by excess of lime in the water of the cretinous districts. This has been alleged to account for the mentally-deteriorated state, but has no perceptible connection with the general habit of body. It must therefore be regarded more as an epiphenomenon of the disease rather than as having anything to do with its essential pathology.

There is a close resemblance between the cretinous condition, myxœdema, and the cachexia strumipriva, or that cachexia resulting from excision of the thyroid gland. Hence the question has been raised as to whether they are not all bound up with the same cause, namely, loss in function of the thyroid gland.

Fœtal Cretinism.

It is now known that the fœtus is sometimes born a complete cretin. The morbid state was formerly described as **fœtal rickets.** The soft parts present appearances characteristic of myxœdema. The trunk is short and plump, and the extremities have a stumpy aspect, while the bones are abortive and thick. The abdomen is prominent, and other deformities are present somewhat resembling those of rickets, although not identical with them. The disease, however, differs from rickets in the fact that the thyroid gland either remains undeveloped or is of rudimentary dimensions. The supposition is that this defect accounts for the cretinous condition of body.

EXOPHTHALMIC GOITRE (*Graves' Disease*).

994. **Historical.**—The first distinct description of this disease was given by Graves in the year 1835 (No. 513, p. 220). He referred to three cases, all in females, where violent and long-continued cardiac palpitation was accompanied by swelling of the thyroid gland.

When the palpitations were violent the swelling of the gland became greater. It remained for Stokes, however, in a private letter to Graves, to draw attention to the protrusion of the eyeballs. Shortly after Graves' published observation the disease was more systematically investigated at the hands of the elder Begbie, and the numerous facts accumulated by him took the shape of a Memoir, laid before the Medico-Chirurgical Society of Edinburgh (No. 280) in the year 1849.

The disease about the same time also attracted attention in Germany, and was the subject of a monograph by Basedow (No. 514, 1840), in which he named the affection the "cachexia exophthalmica." On this account it is usually known in Germany as "Basedow's Disease." Since then numerous treatises upon it have appeared, among which may be mentioned specially that of the younger Begbie and of Trousseau (see Bibliog.).

General Phenomena.—The disease may be said to be characterised by (1) palpitation of the heart with throbbing of the cervical arteries; (2) anæmia; (3) protrusion of the eyeballs; and (4) enlargement of the thyroid gland. It is commonest in young women, but also occurs in the male sex. The history of cases shows that very often the disease has come on after the individual has sustained some nervous shock, such as a sudden fright. The symptoms are initiated by palpitation of the heart, and soon afterwards the thyroid is noticed to increase in size. So bulky does the gland become that its pressure occasions a sensation of choking. The eyes next begin to protrude to an extraordinary extent, and an anæmic habit of body sets in.

The eyeballs may protrude so much that the points of insertion of the recti muscles become visible, and the individual experiences a feeling as if they were going to fall out. The eyelids fail to cover the eyeballs, and in some cases ulceration of the cornea takes place. The cause of this extraordinary dislocation of the eyeballs has never been accurately ascertained. By some it is said to be owing to vascular distension; by others to accumulation of fat tissue within the orbit. The recti muscles have been found fatty probably from disuse.

In a very characteristic case occurring in a young woman which came under the author's notice the **thyroid** was enlarged in both lobes, but the isthmus remained of natural dimensions. Each lobe had a somewhat pear or leg-of-mutton shape, the broad end downwards, and measured 2 ins. long by 1 in. at its broadest part. The superior thyroid artery was fairly large and slightly tortuous. In general appearance the gland did not seem to be altered.

The **thymus gland** is sometimes nearly as large as the thyroid, or even larger. In the above case it was much larger, each half measuring 4½ ins. long by 1 in. at its broadest part. The lower end was the broader and thicker, so that each half had a striking resemblance to a dog's tongue. The gland lay in close contact with the anterior surface of the arch of the aorta, and extended beyond this for a distance of 2 inches over the pericardium. The inferior extremity was free, while the upper ended in a tendinous structure attached to the loose cellular tissue around the upper end of the trachea.

Pathology.—On this subject we know next to nothing. In the great majority of cases the heart is sound and no lesions beyond those of the parts mentioned can be recognised. It has been held that the sympathetic is at fault, but such a statement is purely supposititious. From the fact that the disease is often recovered from, it might be inferred that it is not due to any irreparable organic mischief. Greenfield and others have argued that the symptom complex is the result of some irritant poison generated in the thyroid.

The same author (No. 6, 1893, ii. p. 1262) describes the pathological alterations of the gland as twofold, namely, a proliferation and alteration to a columnar type of the epithelium lining the vesicles, and (2) the production of an enormous number of newly-formed tubular spaces lined by a single layer of cubical epithelium. So marked is the proliferation of epithelium that the appearance resembles that of a cystadenoma of the ovary.

OTHER DISEASES.

995. The thyroid sometimes becomes extremely vascular, so that a **cirsoid-aneurismal** or **nævus-like dilatation** of its arteries takes place.

Tubercle is of rare occurrence, and the same may be said of **cancer.** A **sarcoma** sometimes grows within its substance, apparently from the interstitial tissue.

Literature on Thyroid Gland and Myxœdema.—**Begbie** (Exophthalmic Goitre): Collected Works, Syd. Soc., p. 169. **Beresowsky** (Compensatory Hypertrophy): Beitr. z. path. Anat. u. z. allg. Path., xii. 1892, p. 122. **Berry** (Lectures on Goitre): Brit. Med. Journ., 1891, i. p. 1269 *et seq.* **Billroth and Lücke:** Deut. Chirurg., Lief. xxxviii. **Christiani** (Thyroidectomy): Arch. de physiol. norm. et path., v. 1893, pp. 39, 164. **Discussion on Myxœdema:** Brit. Med. Journ., 1883, ii. **Gley** (Researches on the Thyroid): Arch. de physiol. norm. et path., iv. 1892, p. 311. **Gordon** (Effect of Removal): Brit. Med. Journ., 1886, ii. p. 65. **Graves** (Exophthalmic Goitre): Clinical Lectures, Syd. Soc., ii. p. 220. **Gull** (Myxœdema): Trans. Clin. Soc. Lond., vii. 1879, p. 180. **Hofmeister** (Physiol. of Thyroid): Fortschr. d. Med., x. 1892, pp. 81, 121. **Horsley:** Rep. to Committee of Brown Institution, 1885; *also*, Brit. Med. Journ., 1885, i. p. 211; *Ibid.*, 1892, i. p. 215; *also*, Lancet, 1886, ii. p. 1163; *also*, Virchow's Festschrift, 1891 (with Historical References). **Kopp** (Changes in Nerv. System after Excision of the Thyroid of Dogs): Arch. f. path. Anat., cxxviii. 1892, p. 290. **Langendorff:** Arch. f. Physiol., 1889, Suppl.-Bd., p. 218. **Ord** (Myxœdema): Med. Chir. Trans., xliii. 1878; *also*, Trans. Clin. Soc., xiii. 1880, p. 15. **Report on Myxœdema:** Clinical Soc. Lond. Trans., 1888. **Stokes** (Effect of Removal): Brit. Med. Journ., 1886, ii. p. 709. **Trousseau:** Clinical Medicine, Syd. Soc., i. 1867, p. 542. **Waldeyer** (Anatomy): Berl. klin. Wochnschr., xxiv. 1887, p. 233. **White** (Myxœdema): Lancet, 1885, i. p. 343; *also* (Variations), Brit. Med. Journ., 1888,

i. p. 587. In addition to refs. given, see also cases reported by Cavafy, Duckworth, Harley, Lunn, Nixon, etc., in the Trans. Med. Chir. Soc., Lond., and in Trans. Clin. Soc. Lond. For general literature on treatment of Myxœdema by supplying thyroid secretion, consult Brit. Med. Journ. for last three years.

SUPRA-RENAL CAPSULES.

Anatomical Details.

996. The supra-renals are possessed of a cortical and a medullary substance. The cortex can be divided into three layers, all rich in cells. The cells of the innermost layer contain pigment. The medulla is made up of a fibrous stroma in which numerous nerve cells of various shapes are embedded. From those which lie peripherally delicate processes stretch into the innermost of the three cortical layers. So abundant are these nerve cells that the supra-renal bodies have been regarded as ganglionic nerve centres. In support of this view they are known to be closely bound up with the solar plexus and semilunar ganglia, and numerous nerve twigs from the vagus and phrenic pass into them. They are prominent organs in mammals, birds, reptiles, amphibians, and fishes.

Effect of Removal.

In Man they are most developed at the time of birth and suffer decay in adult life, so that in middle and old age they are very often found to consist simply of the sac-like fibrous capsule of the gland enclosing a little brown pultaceous substance.

Notwithstanding this, however, recent experiments seem to point to the supra-renals subserving a most important purpose in the system. Abelous and Langlois (No. 94, iv. 1892, p. 165) have shown that a fatal result follows when they are destroyed in frogs by the actual cautery. The animals survive from two to thirteen days and suffer from muscular incoordination, followed by paralysis. The blood of an "acapsuled" frog when injected into the blood-vessels of a sound frog induces the same phenomena, and a like result also ensues on the injection of the blood of an "acapsuled" guinea-pig into the circulation of the frog. Following out Bernard's well-known method of investigating the influence of poisons like curare by progressively ligaturing the vessels of a limb before the injection of the poison, they have come to the conclusion that the action of the blood of an "acapsuled" animal resembles in its poisonous effects those of curare. There is evidently a toxic product contained in the blood which acts very much as curare does, and which presumably is destroyed in health by something secreted by the supra-renal bodies. When these bodies are removed this poisonous substance accumulates in the blood and induces the symptoms above referred to. It has been supposed, although without sufficient basis of support, to be neurin. A piece of an adrenal cut off and introduced into the dorsal lymph-sac of an "acapsuled" frog serves to prolong its life.

ADDISON'S DISEASE.

997. The supra-renals gained most of their early pathological importance from the discovery made by Addison (No. 510) that their destruction is often accompanied by a peculiar disease, in which pigmentation of the skin and sometimes of other parts of the body is one of the most striking features.

General Phenomena.—The characteristics of this remarkable disease, as originally pointed out by Addison, are, firstly, that it is essentially a form of **anæmia,** and secondly, that it is accompanied by **pigmentation of the skin.** The pigmentation varies from a dull bluish-green to a brown mulatto tint, and is most marked on the face and neck, the axillæ, front of abdomen, inner aspect of thighs, and external genitals. It is also sometimes seen on the mucous membranes of the lip and mouth and on the mesentery and omentum. The sclerotics, however, maintain their pearly aspect even to an unduly great extent. There is also great wasting of the body, and a general falling off in health with indisposition for any exertion mental or corporeal. Pain in the epigastrium and feeble heart's action are often noticed.

The pigmentation is sometimes quite diffuse; at other times there are black spots upon perhaps a mulatto-base. White patches may alternate with areas of pigmentation.

The Capsules.—These are usually hard, nodulated, and enlarged. Sometimes, however, the enlargement is not at all evident. They are often extensively bound to neighbouring organs by old fibrous union. On section the line of demarcation between cortex and medulla will be found to have vanished. Several cheesy deposits may be seen lying in their substance, some of them not unfrequently calcic. The lymph-glands in the neighbourhood are usually swollen and the solitary glands and Peyer's patches of the intestine have often been found enlarged. A mammillated condition of the stomach and enlargement of the spleen are epiphenomena. The matting together of the parts by the adhesions tends to involve the nerves, ganglia, and plexuses in the neighbourhood. It has been stated, moreover, by Greenhow (No. 264, 1881, ii. p. 69) that these may be found thickened from increase of their neurilemma.

It must not be supposed, however, that the caseous condition of the bodies above referred to is invariable. Addison himself described them (Case IV.) as sometimes being small and atrophied, as he supposed, from the effects of inflammation. And since then numerous instances of the occurrence of the disease in connection with simple wasting of the bodies have been put on record (see No. 192, xxxvi. 1885, p. 427 *et seq.*). It has even been asserted by Tizzoni (No. 511, xii. 1884, p. 361) that removal of the glands in the rabbit is followed by a brown pigmentation of the muscles and of the mucous membrane of the nose and mouth. When one gland is excised the pigmentation is mostly on the corresponding side. Against this, however, are to be reckoned the experiments of Nothnagel (No. 91, i. p. 77), who destroyed the capsules in 153 animals without finding pigmentation or any other phenomenon worthy of mention.

Cancerous disease was also found by Addison (Cases VII. and VIII.) to occasion the pigmentation. It does not always do so, the result depending most likely upon the amount of destruction of the glands which ensues.

Pathology.—The key to the pathology of the disease of course is to be found in great part in a right interpretation of the pigmentary functions of the capsules. An old notion (Jaquet, No. 4, v. 1878, p. 390) which has been revived by M'Munn (No. 6, 1888, i. p. 234) is that their function is mainly to break up refuse pigment and to fit it for being excreted by the kidneys or liver. As before said, the supra-renals contain a pigment. This, according to M'Munn, has not as yet been isolated. It gives the absorption bands of hæmochromogen or reduced hæmatin, more especially when taken from the medulla. On practically all occasions in which he has found this pigment in the animal kingdom it has been excretory, and he supposes that it has the same significance when present in the adrenals—that it is, in fact, evidence of a downward metamorphosis of worn-out pigments, the hæmoglobins and histo-hæmatins. One of the functions of the supra-renals, he supposes, is to pick out effete pigments from the circulation. Hence where they are destroyed pigmentation ought naturally to take place from these effete pigments accumulating in the blood, and some of the incompletely metabolised pigment should be present in the urine. Such colouring matter he has isolated from the urine in Addison's disease, and names it urohæmatoporphyrin. The adrenals, however, are probably not alone in this function. An occasional absence of pigmentation when they are destroyed may be accounted for by the pigment being metamorphosed and removed through other agencies. Thus there may be bronzing without disease of the adrenals, or disease of the adrenals without bronzing, because apparently the glands are supplementary organs.

Another view of the accumulation of pigment was held by Holmgren (No. 49, 1868, ii. p. 309), namely, that taurocholic acid is formed in abundance in the capsules, escapes into the blood, and destroys the blood corpuscles. The pigment liberated from the corpuscles deposits itself in the skin. This would explain the coexistent anæmia which is unaccounted for by the foregoing theory.

The sympathetic was supposed by Addison to play an important part in the disease, and since his time the notion has gained many adherents. It is possible that through it the whole functions of the gland might be modified.[1]

Aqueous and alcoholic extracts of the adrenals have a toxic effect. They are like ptomaines (Foa and Pellacani, No. 134, ccx. 1886, p. 218). Macmunn, however (*loc. cit.*), regards these as products of destruction of the refuse proteid part of the pigment in its metabolism. Such bodies induce hyperthermia, while the ptomaines mostly induce hypothermia. Hence he is doubtful of their ptomaine nature.

---

[1] For full statement of evidence on this subject consult Kahlden, No. 13, cxiv. 1888, p. 65.

SUPERNUMERARY ADRENALS.

998. In many of the lower animals the adrenals are multiple. In the elasmobranchs they consist of a double row of bodies arranged segmentally.

Accessory adrenals are occasionally met with in Man (see Bibliog.), the commonest site being in the broad ligament. The accessory structure is usually about the size of a small pea. Its presence in the broad ligament is accounted for by the general alteration in position of the genito-urinary organs, which occurs on the approach of extra-uterine existence.

COMPENSATORY HYPERTROPHY.

999. It is asserted by Stilling (No. 13, cxviii. 1889, p. 569) that when the one capsule is destroyed in rabbits the other hypertrophies. It appears to increase in size and weight, but whether it really hypertrophies may as yet be held *in retentis*. In this, as in other alleged instances of compensatory hypertrophy, there is a want of detailed examination of the enlarged organ.

TUMOURS.

1000. The commonest of these are cancer, sarcoma, blood-cysts, etc. Primary cancer of one or of both capsules has been frequently described. In many of the cases, and particularly where both have been simultaneously affected, other organs have been implicated, and doubt may therefore be thrown upon its having been primary. Sarcomata sometimes grow to a great size. The blood-cyst appears to originate in a hæmorrhage into a capsule already hollowed out, as so frequently happens, by senile degeneration. Pigment crystals separate freely from the effused blood.

Literature on the Supra-renal Bodies.—**Addison**: On the Constitutional and Local Effects of Disease of the Supra-renal Capsules, 1855. **Alexander** (Researches on Supra-renals and Nerv. Syst.): Beitr. z. path. Anat. u. z. allg. Path. (Ziegler). **Averbeck**: Die Addison'sche Krankheit, 1869. **Barlow** (Addison's Disease): Trans. Path. Soc. Lond., xxxvi. 1885, p. 433. **Burger**: Die Nebennieren u. d. Morbus Addisoni, 1883. **Chiari** (Accessory): Zeitschr. f. Heilk., v. 1884, p. 449. **Coupland**: Trans. Path. Soc., xxxvi. 1885, p. 423. **Dagonet** (Path. Anat.): Zeitschr. f. Heilk., vi. 1885, p. 1. **Discussion on Paper by Greenhow**: Trans. Internat. Med. Cong. Lond., 1881, ii. p. 51. **Goodhart**: Trans. Path. Soc. Lond., xxxiii. 1882, p. 340. **Greenhow**: Brit. Med. Journ., 1875, i. p. 327 *et seq.* **Hausmann** (Primary Cancer in Both): Berl. klin. Wochnschr., xiii. 1876, p. 648. **Kahlden** (Path. Anat.): Arch. f. path. Anat., cxiv. 1888, p. 65. **Macmunn**: Brit. Med. Journ., 1888, i. p. 233. **Marchand** (Accessory): Arch. f. path. Anat., xcii. 1883, p. 11. **Saundby**: Brit. Med. Journ., 1883, i. p. 50. **Stilling** (Compensatory Hypertrophy): Arch. f. path. Anat., cxviii. 1889, p. 569. **Wolff** (Addison's Disease): Berl. klin. Wochnschr., vi. 1869, p. 173.

THE SPLEEN.

Anatomical and Physiological Details.

1001. On the vexed question of how the blood passes from the splenic artery into the splenic vein there are chiefly two views. The first is that the terminal branches of the artery open directly into the splenic sinuses and thence into the veins. The second is that the terminal offshoots open first into the sponge-like network of the pulp, that the blood-corpuscles are thus retarded in their progress onwards, and that from the meshes of the pulp network they penetrate by minute apertures into the sinuses, while these again are continuous with the veins. Of the two, the latter is much the more deserving of acceptance. And the reasons for this are mainly the fact that the pulp is extremely porous; that it is impossible to trace by methods of injection, staining by silver, or otherwise, any direct connection between the arteries and veins; and that, when the organ is engorged with blood, the pulp interspaces become distended therewith. Evidence is also afforded by the study of the spleen in waxy disease strongly favouring the latter notion. It is, accordingly, the view which will be taken of the structure of the organ in what follows.

The splenic sinuses are very delicate spaces of irregular shape, which in the healthy spleen are seen with difficulty, but which become much more evident in certain morbid conditions. They are lined with endothelium, which is continuous with that of the veins. They are, in fact, small cistern-like cavities which subserve the purpose of collecting the blood from the pulp before it starts on its passage through the venous channels. Distinct apertures can be seen between their endothelial plates in conditions of engorgement of the pulp reticulum, and it is through these apparently that the blood-corpuscles make their way in passing from the one into the other.

The blood, on account of its diffusion throughout the pulp, is hindered in its course from the arteries to the veins, and seeing that the blood-corpuscles undergo profound alterations in the spleen, there appears to be a purpose in this arrangement, just as in the case of the circulation within the red bone marrow (vol. i. p. 489).

The essential circulation through the spleen, it must be borne in mind, therefore, is without capillaries. The sinuses appear to be their homologue. It must not be forgotten, however, that this is true only so far as regards what may be called the physiological circulation through the organ. Within and around the Malpighian bodies, the muscular trabeculæ, and capsule there are true capillaries which apparently are independent of the pulp circulation. There are indeed, so to speak, two circulations in the organ, the one probably bound up with its blood-forming functions, the other concerned with the maintenance of the structure of its various parts.

The organ contains much unstriated muscular tissue in its capsule and trabeculæ, and pulsates rhythmically and independently of the pulsations of the heart (Roy).

VENOUS ENGORGEMENT.

1002. In conditions of embarrassed circulation, such as that resulting from valvular disease of the heart, the spleen becomes altered in texture and general appearance. It increases in size and becomes particularly hard and elastic. The capsule has a deep blue or purple colour, and on section the spleen substance is seen to be almost perfectly black from venous hyperæmia. The colour becomes brighter red on exposure, the cut edges are sharp and well defined, and very little blood can be squeezed out from the organ. The Malpighian bodies may be well defined or not. As a rule they are distinctly enough seen.

The pulp and sinuses are packed with blood-corpuscles, and this accounts for the elastic resilience felt on handling it. The muscle of the trabeculæ is sometimes a little hypertrophied, but there does not usually appear to be any deposition of new fibrous tissue nor of blood pigment.

THE WAX-LIKE SPLEEN.

1003. There are two varieties of this disease, differing according to the parts implicated. The one is known as the "Sago Spleen," the other is the "Diffuse wax-like Spleen." The former is by far the commoner of the two.

The Sago Spleen.

The organ is somewhat enlarged and increased in weight (7-10 ounces) and consistence, but in none of these respects to so great a degree as in the diffuse form of the disease. The capsule is somewhat stretched, but not to the extent of its being attenuated. On section, the cut edges are sharp, the surface dry. The Malpighian bodies are enlarged, prominent, and have the peculiar lustre of masses of boiled sago. They are in reality almost colourless, but, against the splenic pulp which always retains its colour, they appear dark red or almost black. When the disease is at all advanced they do not present a gray tint. If, however, the infiltration of the Malpighian body with the amyloid is only partial, a certain amount of its natural gray tint may still remain.

On staining with iodine the enlarged Malpighian bodies alone are the parts which seem, so far as naked-eye examination is concerned, to give the brown reaction.

Examined microscopically, in the unstained condition these Malpighian bodies are seen to be from three to four times their average size;

they have a remarkable translucency and a sharp well-defined border. The artery in their midst is usually waxy, but not always so. The remainder of the organ does not appear to be much altered, but when stained with gentian-violet some of the branches of the small arteries entering the pulp give the pink reaction along with occasional localised deposits of the waxy in their vicinity. The greater part of the pulp, however, remains of a slate blue or purple colour, showing that the waxy disease has not extended to it.

In many cases the infiltration of the Malpighian body is incomplete, and in these there is a chance of studying where the amyloid is derived from. It is often asserted that the small round cells of the Malpighian body degenerate into it, and certainly there are appearances which at first sight seem to favour the view. With gentian-violet the leucocytes stain blue, the waxy pink; and these blue leucocytes are often found adhering to the pink masses of waxy in such a manner as to make it appear as if they were their source. Such appearances, however, are deceptive. If due care be adopted in the examination, it will be found that here as elsewhere the disease presents the characters of an infiltration—an infiltration of an albuminous substance derived from the blood—into the interstices of the stroma constituting the groundwork of the Malpighian body.

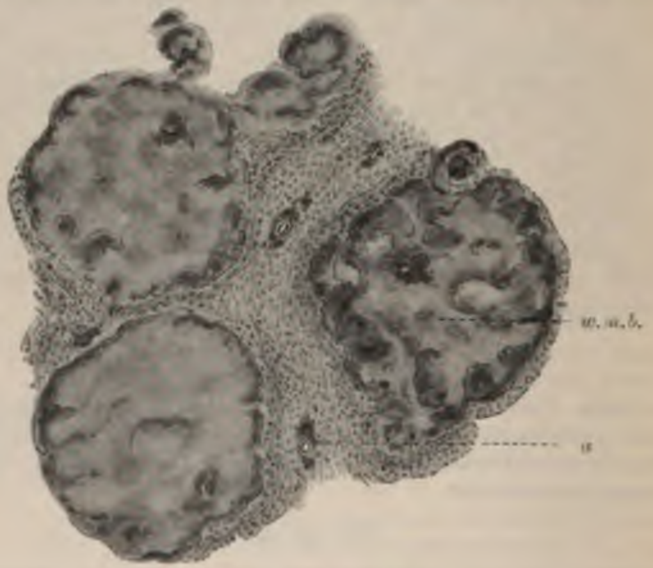


FIG. 483.—SAGO SPLEEN (×50 DIAMS.)

(*w.m.b.*) Waxy Malpighian body; (*a*) small artery in the splenic pulp surrounded by the waxy (Gentian-violet and Farrants' Sol.)

Diffuse Waxy Spleen.

1004. This, as aforesaid, is larger, heavier, and firmer than the "sago" variety. So firm is it that it has the feeling of a waxy liver. It is also comparatively anæmic, but, like the waxy spleen in any form, the pallor is never so great as in other organs. The cut surface is particularly dry and is not differentiated by sago-like masses. It presents the uniform dry lustre of a wax model. The Malpighian bodies may be present, but are not waxy, or only very partially so. More constantly they are entirely absent. The stain given with iodine, when seen with the naked eye, is quite diffuse; the whole pulp substance is equally coloured of a dark brown tint.

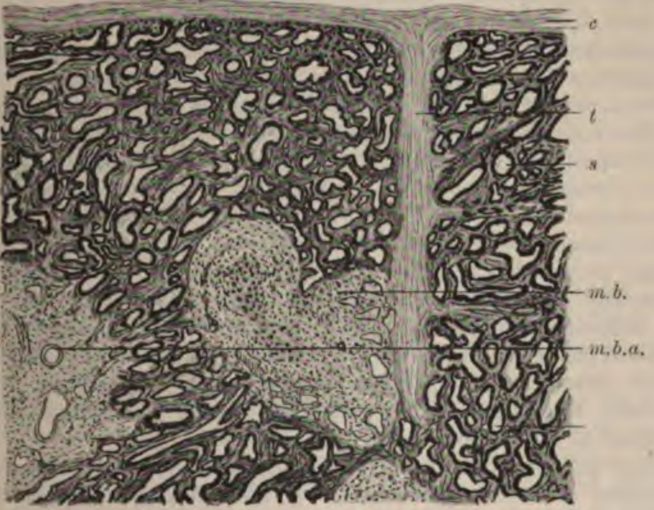


FIG. 484.—DIFFUSE WAXY SPLEEN (×50 DIAMS.)

(*c*) Capsule with a muscular trabecula (*t*) running inwards from it; (*m.b.*) Malpighian body, somewhat enlarged but not waxy; (*m.b.a.*) another of the same with a waxy artery in its midst; (*s*) sinuses of the splenic pulp, each with its wall infiltrated with the waxy. The dark shading of their walls corresponds to the pink reaction (Gentian-violet).

The chief seat of deposit of the amyloid is in the walls of the **splenic sinuses,** which, instead of being structures indistinctly visible on account of their extreme delicacy, are now readily recognised with a magnifying power of fifty diameters. The wall is infiltrated either throughout its entire extent or only on one side, and gives a brilliant pink colour when stained with gentian-violet. The cavities of the sinuses are usually empty and dilated, but if there happens to be a little blood contained in them, it gives a blue colour, not a pink reaction. The endothelium lining the sinuses is often retained and also colours blue.

In severe cases the greater part of the reticular tissue is similarly infiltrated, so that the pulp substance may show a universal pink stain. The small arteries are invariably waxy; but both in this and in the "sago" variety the muscular trabeculæ and the capsule remain free from infiltration, unless where a waxy vessel runs through either of them or lies in their neighbourhood. The immediate surroundings, under such circumstances, usually give a slight pink reaction.

TUBERCLE.

1005. The spleen is a common seat of tubercle when the disease takes the form of a general miliary eruption. There is no such thing known as phthisis of the spleen in the sense in which the term is employed in reference to the lung, kidney, or testicle, the reason being that the spleen is unprovided with epithelial-clad ducts.

The nodules vary in size from a millet seed, or smaller, up to a pea or hazel nut. When they reach the latter dimension the nodule will be found on microscopic examination to be an agglomeration of several smaller masses. Even when they are microscopic objects they will be found to show evidence of incipient caseation, and when they become perceptible to the naked eye they derive a distinctly yellow colour and dry consistence from this cause. They frequently calcify, and sometimes so generally that every nodule within the organ may be found converted into a stone-like mass. Curiously this may happen in the spleen to the exclusion of other organs which may be simultaneously tubercular. They sometimes soften and cicatrise, but do not tend to become excavated.

The giant-cells are usually abundant in the nodules, but a complete reticulum is seldom encountered. The tubercle bacillus is often difficult to demonstrate.

In the case of the **horse,** tubercle of the spleen sometimes takes the form of a huge sarcoma-like mass many pounds in weight and containing the bacillus abundantly.

SYPHILITIC SPLEEN—PERISPLENITIS.

Where there is evidence of abdominal syphilis, the surrounding adhesions will usually be found to implicate the spleen. Gummata and the cicatrices resulting from them may occasion considerable deformity of the organ, and they are accompanied by thickening of the capsule. The lesions assume the character of a perisplenitis more than that of an inflammation of the organ itself.

There is a form of **thickening of the capsule** met with pretty often, which is peculiar in so far as it gives rise to an appearance as if melted tallow had been poured over the surface and been allowed to consolidate. The thickening is caused simply by a fibrous deposit. The commencement of the disease is probably a precipitation of fibrinous lymph on the capsule; this subsequently becomes organised. The spleen, however, need not be adherent to neighbouring parts. The disease may possibly in some cases be a syphilitic affection.

Baumgarten (No. 13, xcvii. 1884, p. 21) describes a form of **miliary eruption** in the spleen almost identical with tubercle, but which, he says, is syphilitic. So close does the drawing he gives of it resemble tubercle that it would require even more convincing evidence than he adduces to entirely discredit the possibility of its being such.

CAVERNOUS TUMOUR.

1006. Sometimes the entire spleen becomes swollen and engorged. From a dilatation of its blood channels it may pulsate like an aneurism. In a case of this kind described by Langhans (No. 13, lxxv. 1879, p. 273) angeiomatous masses were also found in the liver. The spleen in that case was 23 ctm. long, 15 ctm. broad, and 10·5 ctm. thick.

CANCER.

1007. Secondary cancer of the spleen is common enough, and it has been alleged that primary cancer has been met with. Notta (No. 107, 1886, i. p. 166) has collected all the supposed cases together, some ten in all, and himself believes in its occurrence. On reading over the records of the cases, however, the evidence upon which the diagnosis of a true primary epithelial tumour was based is, to say the least of it, meagre. The only conceivable manner in which such a tumour might originate would be by some embryological epithelial remnant such as a dermoid having got included in the splenic tissue.

SARCOMA AND LYMPHADENOMA.

1008. Primary sarcomata undoubtedly grow from the organ. Lymphadenomata in the human subject are almost always secondary. The primary yellow tumours formerly described as such generally turn out to be tubercle.

AGUE SPLEEN.

1009. The spleen in malarious disease becomes much enlarged and peculiarly brittle, so that a slight blow will serve to rupture it. When in this swollen and brittle state the term "ague cake" is applied to it. In chronic cases the organ becomes tougher, owing to a diffuse cirrhosis of its texture.

Common as the malarious spleen is, yet, curiously, the literature on the subject of the cause of the enlargement is meagre. It is probable, however, that, in the first instance, it is due to accumulated leucocytes, while later on the lesion assumes the character of a diffuse fine cirrhosis.

The malarious spleen is also frequently *pigmented*. The pigment is black and gives to the organ as a whole a peculiarly leaden tint. The particles are small, black, and irregular in shape. The liver as a rule is simultaneously pigmented, and lines of pigmentation are seen in the peritoneum.

(For further particulars consult **Malaria** and **Pigmentation of Liver.**)

TYPHOID SPLEEN.

1010. The organ is swollen, soft, anæmic, and pulpy, but beyond this not much is known of its condition.

For description of the **Leucocythæmic Spleen** and **Infarction** see the respective titles. For that of the blood-forming properties of the organ see *Blood*. Supernumerary Spleens, see *Malformations*.

Literature on the Spleen.—**Baumgarten** (Miliary Syphilis) : Arch. f. path. Anat., xcvii. 1884, pp. 21, 36. **Fleming** (Abscess): Med. Reg., Phila., v. 1889, p. 201. **Griffini** (Partial Reproduction): Arch. per le sc. med. Torino, vi. 1882, p. 312. **Grigorescu** (Circulation, Healthy and Diseased): Compt. rend. Soc. de biol., iii. 1886, p. 501. **Langhans** (Cavernous Tumour): Arch. f. path. Anat., lxxv. 1879, p. 273. **Malinin** (Physiol. and Pathol.): Arch. f. path. Anat., cxv. 1889, p. 303. **Neumann** (Charcot's Crystals): Arch. f. path. Anat., cxvi. 1889, p. 324. **Notta** (Primary Cancer): Arch. gén. d. méd., 1886, i. p. 166. **Roy** (Causes of Rupture) : Indian Med. Gaz., xxi. 1886, p. 235. **Sokoloff** (Venous Hyperæmia) : Arch. f. path. Anat., cxii. 1888, p. 209. **Stilling**: Arch. f. path. Anat., ciii. 1886, p. 15; *see also* Leucocythæmia.

CHAPTER LXXXVII

THE MAMMA

Normal Structure.

1011. **General Structure.**—The human mamma may be regarded not as a single gland but rather as an aggregation of from fifteen to twenty separate glands, each opening on the nipple by an independent orifice. These glands consist of a duct emulging externally into a sac-like cistern in the nipple and dividing internally in a dichotomous manner into acinous or berry-like extremities. The acini in the virgin gland are lined by a double row of epithelial cells. The deep row is somewhat rounded, while the superficial is more or less conical and becomes columnar as the ducts are approached. The epithelium is undoubtedly supported by a *membrana propria.* The structure of this membrane was described originally by Henle (No. 512, ii. p. 46), afterwards in health and disease by Langhans (No. 13, lviii. 1873, p. 132). It is composed of a homogeneous-looking connective tissue continuous with that of the gland generally. The individual segments of the gland are bound together by a peculiarly coarse variety of fibrous tissue, whose bundles are so loosely interwoven that numerous spaces are left between infiltrated with fat. Surrounding the bundles is a peculiarly rich network of **lymphatics,** most of which ultimately drain into the **axillary glands.** Blood-vessels are also abundant.

In a microscopic section of the virgin gland the acini are seen to be arranged in groups of four to six or more, and the groups are separated widely by the surrounding connective tissue. Each group is enveloped concentrically by the connective tissue, and hence is demarcated from surrounding parts. The epithelium of the acini is comparatively ill developed, and contrasts in a marked manner with that seen in cancer and other epithelial diseases.

Liability to Tumour Disease.—Seeing that the gland is provided with so abundant a fibrous stroma, with so rich a lymphatic supply, and with epithelial-clad acini and ducts, it might be expected naturally to be a seat of tumour disease. There is another cause, however, which predisposes it to such, namely, *its great instability*. Secreting milk at the time of birth, lying latent till puberty, undergoing evolution at that period, being the subject of unusual activity during lactation, and again passing into a state of involution during old age, it can hardly be a matter of surprise that it is a frequent seat of tumours of various kinds. And when we consider that during many of these phases of its life history the epithelial investment becomes profoundly modified, it can be understood why so many of the new growths found in it assume an epithelial type.

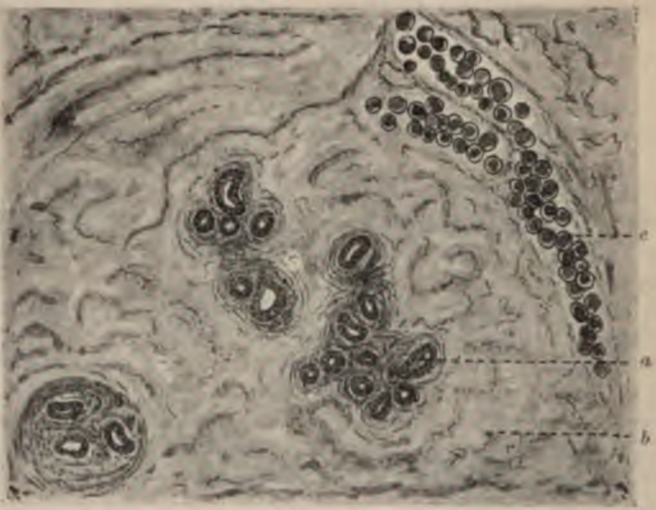


FIG. 485.—NORMAL VIRGIN MAMMA FROM A WOMAN ABOUT TWENTY YEARS OF AGE (×50 DIAMS.)

(*a*) Group of acini and ducts; (*b*) surrounding coarse stroma; (*c*) fat tissue lying in the stroma (Perosmic acid and Farrants' Sol.)

MASTODYNIA (*μαστός, the breast; ὀδύνη, pain*).

1012. Neuralgic pain in the female mamma is of common occurrence in adult life. It is often associated with disease of the uterus, and when this is so the pain is located more in the left than in the right organ. As the glands begin to enlarge at the age of puberty they sometimes become excessively painful, but this differs from the foregoing pain in being elicited mostly when the mammæ are handled or when pressed upon by other means.

THE LACTATING MAMMA.

1013. During lactation the gland becomes large and prominent. The enlargement is due to two causes, first and chiefly, to increase in the gland tissue, and second, to augmented blood-supply.

This increase in gland tissue, from a pathological point of view, is very instructive. Whereas in the virgin gland groups of acini are seen only here and there throughout the section, in the lactating mamma the greater part of the section is taken up by them. The new acini appear to be formed by finger-glove-like protrusions from the old. The channels of the original acini are also widened and the epithelium altered in character. In place of being a double layer in many acini, it seems to become single. The cells have lost their conical shape and

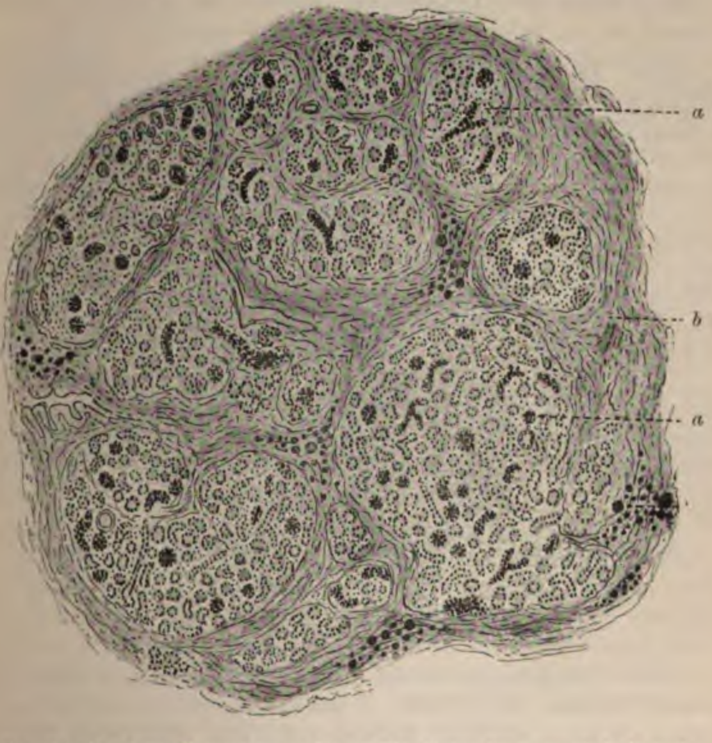


FIG. 486.—LACTATING MAMMA FROM A WOMAN TWO WEEKS DELIVERED (×50 DIAMS.)

(*a*, *a*) Acini with fatty epithelium. The acini are much more numerous than in the virgin gland; the oil globules are blackened by the perosmic acid; (*b*) surrounding stroma with contained fat, also blackened by the perosmic acid (Perosmic acid and Farrants' Sol.)

have become more round or cubical. It looks, in fact, as if the superficial conical layer had vanished and the deep round-cell layer had become more prominent. Nearly every cell contains one or more globules of oil. These vary in size, and in most cases seem to escape into the channel without destroying the epithelium. In some parts, however, the cells are seen to become loosened and detached, and subsequently to suffer granular disintegration.

POLYTHELIA AND POLYMASTIA (πολύς, *many* ; θηλή, *the nipple* ; μαστός, *the breast*).

1014. Accessory nipples without mammary gland and accessory nipples with mammary gland are met with in both sexes. Their site is usually the front of the abdomen, but they have also been found in the axilla or on the back; it has even been asserted that they occur in the inguinal region, but the assertion is probably founded upon an error of observation. When located upon the abdomen they are usually symmetrical, and are arranged in a perpendicular line below the normally-developed glands. Sometimes, however, there are four well-developed mammæ arising in couples from a common base. At other times the mammæ appear to be normal, with the exception of a supernumerary nipple on the lower border of the base of each.

The condition of polymastia is evidently a reversion to an ancestral type where the glands have been multiple. As mentioned under "Dermoid Cysts of the Ovary" (p. 438), a fully-developed mammary gland and nipple have been found in one of these peculiar structures. Their presence in such a situation is difficult to account for.

Absence of one or both mammæ is of very rare occurrence.

HYPERTROPHY.

1015. The difference in size of the breasts in women varies, and is usually the result of a greater or less development of the intervening connective tissue and fat. In some cases, over and above this, there appears to be an excess of gland tissue—a true macromastia or hypertrophy. The glands in such a case become so heavy and pendulous that amputation has been resorted to for relief.

MASTITIS.

1016. Inflammation of the breast often ensues from injury or lactation. In the latter case it tends to terminate in suppuration, and the abscess is situated sometimes in the embedding connective tissue, at other times it also involves the gland structures. The abscess may open and leave a fistula. Occasionally these fistulæ arise from a tubercular source, or they may become tubercular from exposure.

NEOPLASMS.

1017. **Their Classification.**—There are two great divisions of the tumour diseases found in the mammary gland, namely, *into those springing from the epithelium* and *those taking origin from the connective tissue*. To the former class belong the adenomas and cancers, and to the latter the fibrous tumours, the sarcomata, etc. From a developmental point of view the mamma may be regarded as an integumentary gland. Its essential secreting structures are derived from a series of involutions of the embryonic integument. The epithelial cells, however, like those of the sebaceous and sweat glands, lose their tesselated character, and apparently never revert to it even in the various epithelial growths of the organ.

Their Diagnosis.—From the fact that certain tumours spring from the connective stroma, while others are to be traced to the gland elements, the simplest microscopic examination is often sufficient for their diagnosis. For where the new growth has arisen from the interacinous tissue the acini will be found usually to be preserved or to have suffered merely from the pressure of the tumour which lies between them. While in the case of its having sprung primarily from the gland elements, these are either destroyed (cancer) or are brought into unduly great prominence by being overloaded with cells (adenoma). Hence in the diagnosis of any mammary tumour microscopically, *the presence or absence* and *the general condition of the mammary acini and ducts ought to be first ascertained.* If they are entirely or in great part absent from the tumour, the presumption is that the new growth is **cancerous.** If they are present and are packed with epithelium and deformed in outline, the presumption is in favour of an **adenoma.** And if they are present, but in a state of dilatation, without great epithelial excess, or if they are suffering from atrophy while the interacinous tissue is peculiarly dense and abundant, opinion ought to incline to its being of **connective tissue type**—most likely either a **sarcoma** or a **fibrous tumour.**[1]

The state of the nipple is always a matter of importance in the differential recognition of mammary tumours. In the virgin, the section of the gland presents the appearance represented diagrammatically in Fig. 512, A, taken from a frozen section. The nipple protrudes only very slightly above the surface. In the parous woman, and of course more particularly in the woman who is suckling, it is protuberant.

---

[1] The microscopic examination of any tumour of the breast should first and chiefly be made with a low power (50 Diams.). A general scan of a section of the growth under such an amplification when the above points are attended to will yield more information than any other form of inspection.

(1) *Sarcoma of Mamma.*

1018. This tumour usually grows rapidly, so that by the time the patient presents herself for examination the neoplasm has reached a great size, and is often several pounds in weight.

It seems to involve the greater part of the gland, and bulges forwards in a mass of lobulated swellings. The skin is tightly stretched over it, and the superficial veins will probably be found engorged.

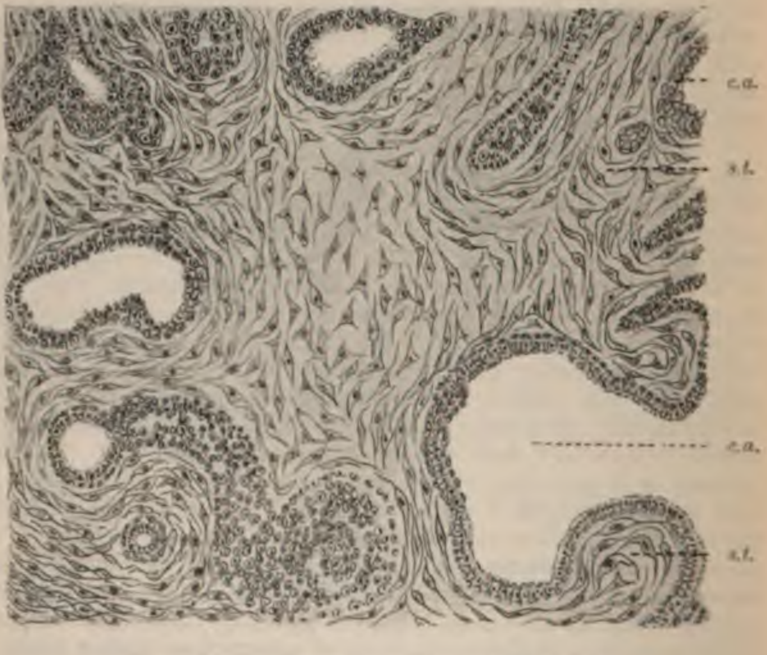


FIG. 487.—CYSTIC SARCOMA OF THE MAMMA (×300 DIAMS.)

(*s.t.*, *s.t.*) Spindle-cell sarcoma tissue; (*c.a.*, *c.a.*) cystic acini and ducts (Carmine, Glacial acetic acid, and Glycerine jelly).

The nipple lies on the surface, but is outstretched and flattened from the great bulk of the tumour underneath (Fig. 512, C).

On section, the tumour presents the homogeneous appearance of an ordinary sarcoma, but in its substance are usually numbers of **cysts** containing thin milk, or a thick gelatinous colloid mass. Seeing that the type of sarcomatous growth in the mamma is usually spindle-cell, the consistence of the tumour is tough and elastic. In cases, however, where the tumour is of the round-cell variety, a rare occurrence, it may be so soft as to break down under slight pressure.

The skin is seen on section to be much attenuated; the tumour presses directly upon it, but does not involve it. Sometimes it gives way, and a fungating mass may then protrude composed of sarcomatous granulation tissue.

Throughout the whole tumour there is an almost complete **absence of the mammary fat.** Even microscopically hardly a fat cell is to be seen anywhere. The contrast between such a tumour and the cancer of the breast, in which islands of fat are almost always bound up with the tumour substance, is worthy of note from a diagnostic point of view.

The oval-shaped nuclei of the spindle-cell tissue of which the tumour consists usually stain brilliantly with nuclear staining reagents. The cells are seen to run in bundles which surround the gland acini and ducts. The proper stroma of the gland has entirely vanished. The gland elements will sometimes be found of natural size, or even partially atrophied, but more often they are irregularly dilated so as to form various-sized cystic cavities. They are often invested with a double or triple epithelial covering, some of the cells of which may have fallen into the cavity. Within many of the dilated acini a quantity of granular matter is often seen.

The occurrence of these cysts is to be explained most likely upon the theory of retained secretion. The tumour grows insidiously and invades the gland by degrees. It gradually supplants the proper intertubular stroma by its own special type of cell. In doing so it surrounds portions of the tubular apparatus of the mamma, and leaves others comparatively free. At the same time it appears to excite the epithelium of the acini to secrete milk or colloid, which, not finding a free outlet, accumulates and causes distension where the pressure of the tumour mass is least. In course of time, however, the invasion of the tumour becomes universal, and then the cysts are found lying in the interior of the new mass.

Occasionally, but rarely, these tumours have melanotic tendencies especially in the lower animals, and particularly in the bitch. More commonly in Man they become the subject of myxomatous degeneration.

(2) *Fibroma.*

This is usually a single tumour; sometimes, however, it is double, triple, or multiple; and it may happen that both mammæ contain them simultaneously. Whereas the sarcoma tends to infiltrate the gland more and more, owing to its excessive activity, this tumour grows usually only to the size of a filbert or a walnut, and then becomes stationary. So that while the sarcoma may be regarded, so to speak, as a tumour or swelling *of* the mamma, this may be described appropriately as a tumour *in* the mamma. It is a little sharply-defined, hard, and isolated mass, somewhat deeply seated as a rule and not adherent to the skin. The nipple usually remains unaffected by it (Fig. 512, B).

Examined microscopically, the tumour mass, if young, will be found to consist of a highly nucleated fibrous deposit, encircling the gland acini in all directions and strangling them. Indeed some of these tumours are so highly nucleated that it is just a question whether they should be called fibrous tumours or sarcomata. When the growth becomes quiescent the tumour tissue assumes a more coarsely fibrous texture, and the nuclei or nucleated fibro-blasts almost entirely vanish. The fibrous tissue now contracts and induces atrophy of the enclosed gland elements. The epithelial cells become small, shrivelled, and granular, very much as the epithelium of the kidney tubes does

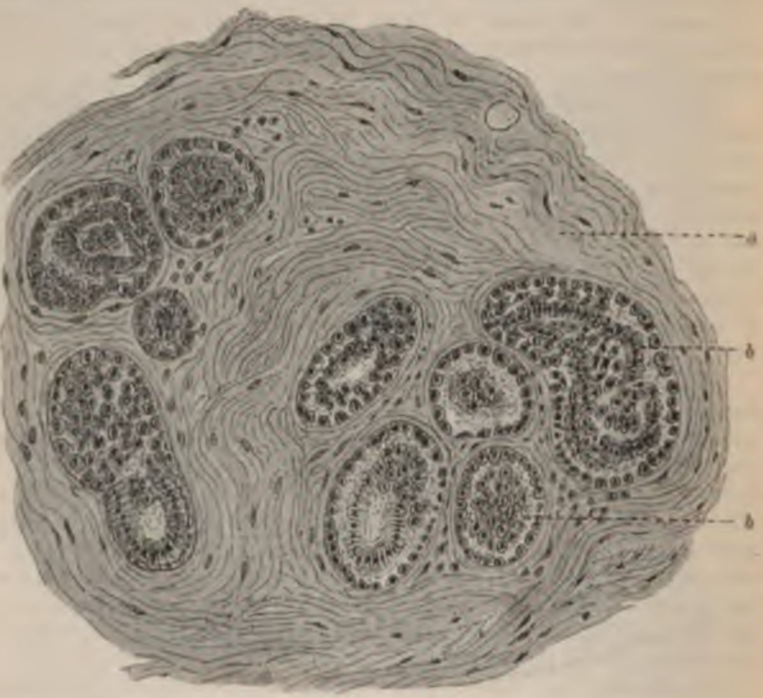


FIG. 488.—FIBROUS TUMOUR OF THE MAMMA (×300 DIAMS.)

(*a*) Fibrous tissue of the new growth much finer than that of the normal breast, and devoid of fat; (*b*, *b*) enclosed acini (Picro-carmine and Farrants' Sol.)

under similar circumstances. Many of the acini are ultimately destroyed.

Cysts are not so common in this tumour disease as in sarcoma, although occasionally they may be seen. The reason for their non-appearance seems to reside in the fact that the fibrous tissue contracts so forcibly as to destroy everything within its grasp. In the cystic sarcoma the tumour, on the contrary, spreads between the gland elements without contracting, and hence presses unequally upon the gland elements.

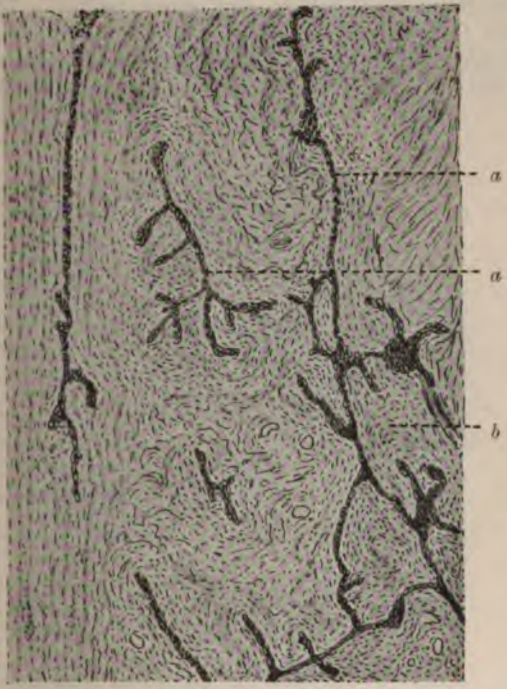


FIG. 489.—FIBROUS TUMOUR OF THE MAMMA, WITH ELONGATED GLAND ACINI ARRANGED IN A RETICULAR MANNER (×50 DIAMS.)

(*a*, *a*) The elongated acini ; (*b*) the new fibrous substance of the tumour (Logwood, Picric acid, and Farrants' Sol.)

This tumour as a rule is benign, and can be excised locally without recurring. There are cases on record, however, where a tumour, passive in its tendencies and evidently of this kind, has suddenly burst out into embryonic activity and assumed sarcomatous characters. It sometimes becomes myxomatous.

(3) *Adenoma.*

1019. A fibrous tumour is often diagnosed as an adenoma. The two tumours are of course quite different. In the fibrous tumour, although gland elements are included, they suffer atrophy, while in the adenoma their increase in number and size is the essential feature of the disease.

The tumour in its purely adenomatous phase is sharply circumscribed, and lies embedded in the gland tissue. The border is defined, and the substance has almost the hard consistence of a cancer. In fact the tumour looks extremely like a cancer, with the exception that it is more circumscribed and has a more regularly rounded shape. There are sometimes several of them in one gland. It appears to have little influence upon the nipple, and does not tend to become adherent to the skin. There is a great inclination to its becoming **cancerous**, so that actually one part of a breast may show the characters of an adenoma while another is distinctly cancerous.

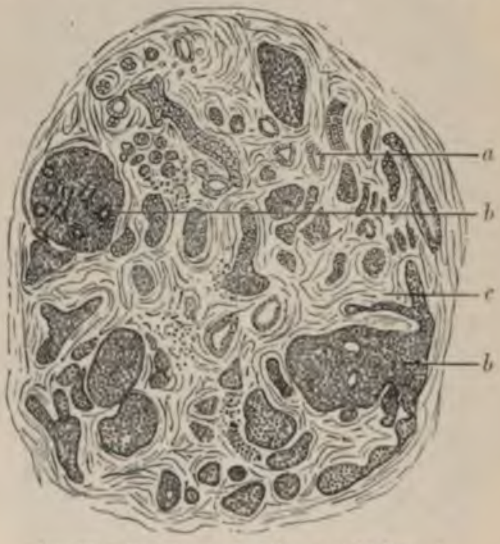


FIG. 490.—ADENOMA OF THE MAMMA (×50 DIAMS.)

(*a*) Normal acinus; (*b*, *b*) acini distended with epithelium, and with secondary acini in their midst; (*c*) surrounding stroma of the gland (Logwood and Farrants' Sol.)

Examined microscopically, the glandular character of the tumour is its special feature. Huge tuberose acini, or, more properly, spaces filled with growing epithelium, abut closely upon one another, while the intervening stroma seems progressively to recede. The epithelium is polygonal in type, and appears to be moulded into shape by the pressure from neighbouring cells. Sometimes within the distended acini it rearranges itself into tube-like or acinous structures.

This tumour, as aforesaid, frequently passes into a cancer. The manner in which this occurs has been previously described (vol. i. p. 403). It should be remembered, however, that tumours alleged to be adenomata sometimes disappear spontaneously. There is always doubt, however, as to what such evanescent tumours have been.

(4) *Carcinoma.*

1020. Cancer of the mamma may be said practically to be always of the hard or scirrhous type. It commences as a rule somewhat deeply in the gland, and grows up towards the skin, but never, so far as the author has seen, implicates its epithelium—that is to say, in the sense of the latter taking on a cancerous action. The skin in course of time may become adherent to the tumour and ulcerate, but the epithelium of the new growth and that of the integument never seem to coalesce.

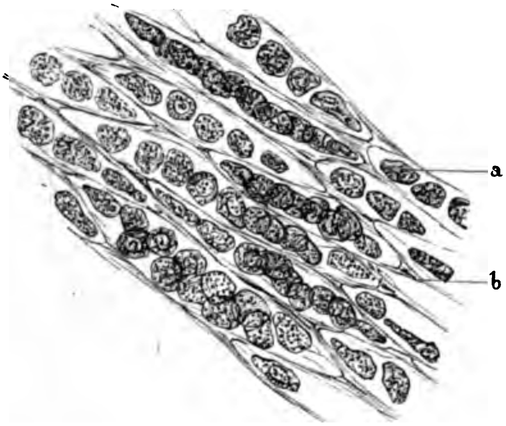


FIG. 508.—CANCER OF MAMMA (×450 DIAMS.)
(*a*) The epithelial cells; (*b*) the stroma (Picro-carmine).

The edge of the neoplasm, as felt through the skin, is not so distinct as in the case of the connective tissue tumours. The mass appears to spread out more irregularly than these growths do. The nipple is often retracted. When so, it will be found that the tumour immediately underlies and is adherent to it.

On section the growth will be found to consist of a central mass, from which processes generally radiate in a stellate manner into the neighbouring fat of the gland. The central mass is very hard, feels in some cases like a dense cicatrix, or even like cartilage, and cuts with a crunching sensation like that experienced in cutting through a raw potato. It has a pinkish colour, and minute yellow fatty spots are generally seen upon its surface. The processes in piercing into the neighbouring fat cause its absorption. Little islands of fat are enclosed and in course of time disposed of (Fig. 512, D).

Although these processes are very characteristic of cancer of the breast, yet it ought to be borne in mind that occasionally the border of the tumour is comparatively regular, like that of an adenoma. Indeed without microscopic examination in these cases it is impossible to say whether we have to do with the one or the other.

The ulceration may commence at any part of the overlying skin. Sometimes it shows first in the areola and remains circumscribed to it.

All these tumours contain much fibrous stroma, and this having an inherent tendency to contract, the tumour, instead of causing a protrusion, may bring about a shrinking of the parts. To such the term **atrophic cancer** is sometimes applied.

When the tumour has been allowed to go on growing without any attempt at removal, or when it has recurred possibly several times, after removal, a crop of secondary nodular growths may develop in the neighbouring skin and immediately subjacent tissues so extensive that the whole of the front of the chest may become covered with them.

The **axillary glands** early become infected, and the structure of the new growth in them is identical with that of the original neoplasm.

Examined microscopically with a low magnifying power, the most striking feature, if the section be taken from the centre of the tumour, is the paucity or absence of gland elements. A section of a duct may occasionally be seen embedded in the cancer tissue, but in many preparations not even such a remnant of the mammary structure remains. This is accounted for, at the point of origin of the tumour at any rate, by the transformation of the gland acini into the cancer structure (vol. i. p. 403).

Granted that this is so, how is it that the remainder of the gland disappears? We must admit either that the epithelium of other portions of the gland becomes cancerously infected from the primary focus, or that their destruction is the result of atrophy and absorption from the ingrowth of the actively growing cancer mass among the gland ducts and their terminations. The latter seems to be the more likely explanation, for the neighbourhood of a duct or an acinus is sometimes seen to become invaded by cancer without any preliminary distension of the channels of these structures with epithelium. The only alteration within the gland elements under such circumstances appears to be of a retrogressive, not of a progressive character. The disease seems to start evidently within one of the fifteen to twenty separate glands of which the mamma consists, and to be confined to this in the adenomatous stage But after the epithelium has escaped into the surrounding stroma it ramifies through all the mammary lymph spaces, distends them, and thus converts them into the alveoli of the tumour.

The stroma is often extremely fine and the meshes small. It differs from the fibrous tissue of the healthy gland in its peculiar fineness. In some old cancers, more especially such as have undergone fatty degeneration, no doubt, it may be coarser, but even in these it has not the same characters as that of the normal gland. It is also more highly nucleated, and many fibroblasts may be met with in it. The stroma of the tumour is not merely the fibrous tissue of the gland, but that tissue in a state of proliferation.

The cells of the tumour always possess certain definite characteristics. They are spheroidal or polygonal according to the pressure exerted upon them, and contain one or more large nuclei. They are aggregated in angular alveoli or stretched out in single rows into tube-like spaces within the surrounding stroma. This tubular sort of arrangement is peculiarly characteristic of mammary cancer. They sometimes become *fatty*; more rarely they undergo *colloid degeneration.* The stroma, when either of these occurrences takes place, is left dissected out.

(For description of the transformation from the adenomatous to the cancerous stage of the tumour, see vol. i. p. 403.)

Paget's Disease of the Nipple.—In the year 1884 Paget (No. 437, x. p. 87) drew attention to a peculiar affection of the skin of the nipple and areola which often precedes the appearance of a mammary cancer. He compared the disease to what would be termed in dermatology "chronic eczema," "psoriasis," or something of this kind.

It rarely shows itself before the age of forty years, and, affecting the parts at first superficially, is followed by a cancerous infiltration of the gland in from two to six years afterwards. The disease is almost always unilateral, and usually commences by the formation of small crusts or horny accretions, which on being removed show an underlying rosy red basis—it may be a little ulceration, or even a fissure or two. Elsewhere the lesion asserts itself as an erythematous or slightly scaly affection of the skin. In course of time this may also become ulcerated, granular, and cracked. The disease is distinguishable, however, from ordinary eczema by the condition of the border, which is sharply demarcated from the healthy skin and is raised up into a pale, rosy, cushion-like pad. The nipple tends to become retracted and the disease spreads successively farther and farther outwards.

Thin held (No. 192, xxxii. 1881, p. 218) that the affection is neither an eczema nor any known specific skin disease, but "a destructive dermatitis of the papillary layer," and he supposes that it is induced by a cancerous affection of the lactiferous ducts—a so-called duct cancer—close by their exit upon the nipple. The morbid ducts throw out a secretion which induces the skin affection in question. Whether the appearances he figures (*e.g.* Fig. 4) can be regarded as those even of incipient cancer may be open to question. They closely resemble desquamative or catarrhal conditions met with in the ducts under other circumstances.

Wickham (No. 519) confirms Thin's observation of the ducts being filled with proliferating epithelium, but takes the view that the affection is essentially a parasitical one, due to the presence of psorospermia.

In two papers presented to the Société de biologie[1] Darier described how he had found **psorospermia** in the epithelial cells of the epidermis of the parts affected by this disease, and traced the condition of the skin to a parasitical origin. In this country Hutchinson jun. (No. 192, xli. 1890, p. 214) confirmed Darier's observation.

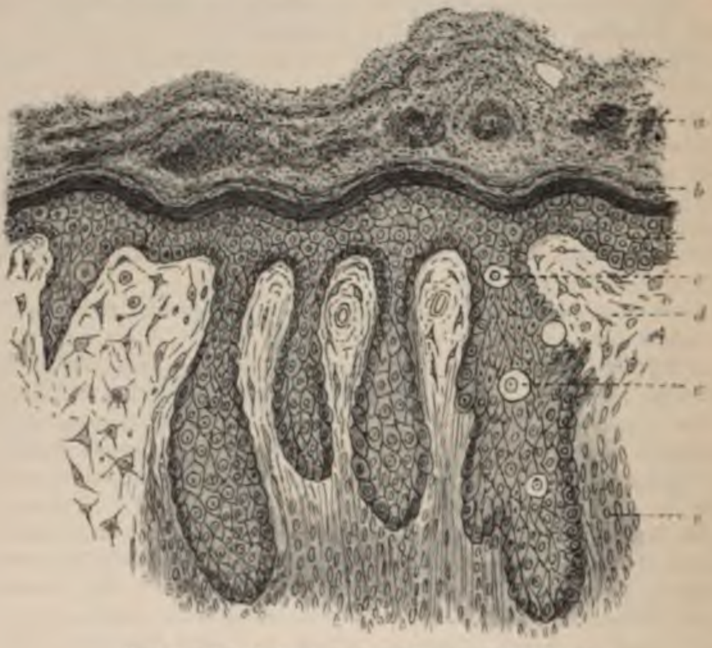


FIG. 509.—PAGET'S DISEASE OF THE NIPPLE (× 300 DIAMS.)

(*a*) Superficial shedding epidermis; (*b*) deep layer of same, with vacuolated cells (psorospermia (?), *c*, *c*) contained in the interpapillary processes; (*d*) half-myxomatous-looking papillary layer of the cutis vera; (*e*) deeper layer of the true skin infiltrated with small round cells (Picro-carmine and Farrants' Sol.)

These psorospermia are referred by Leuckart to the animal kingdom, and are looked upon by him as protozoa. They are unicellular organisms, and are found within vacuoles in the interior of epidermic cells.[1]

---

[1] See Bulletin médical of April 17, 1889, and also the Comptes rendus of the Congrès international de Dermatologie, séance of 8th August 1889. A good account of this and other matters connected with the disease is to be found in Wickham's work already referred to.

According to Wickham, the epithelial cells which contain them proliferate, the epidermis thickens, the ducts of the glands become filled and engorged by the proliferation of their epithelium consequent upon the presence of the psorospermia. The process is accompanied by inflammation. The duct finally bursts, the contained epithelium escapes into the connective tissues of the gland, and a cancer results. The new epithelium meanwhile continues to harbour the organisms in question.

These bodies are found not only in the epithelium of the eczematous nipple and areola, but also later on in that of the cancerous tumour. Hence, although nothing definitely is as yet known of their significance, they are supposed to be in some way intimately related with this and other forms of cancerous disease.

It should be mentioned that this pseudo-eczematous affection of the skin as a precursor of cancer is not confined to the neighbourhood of the mamma, but has been found in other situations such as the scrotum and penis.

(5) *Multiple Colloid Tumour.*

1021. There is a peculiar gelatinous or colloid tumour disease of the female mamma in which the tumours are multiple. They are situated deeply in the gland, are usually about the size of a hazel nut, and have a fairly distinct border. When examined microscopically it is evdent that they are intra- not interglandular formations. They consist of groups of acini distended with a homogeneous colloid substance. The epithelium lining the acinus seems to have become almost entirely converted into colloid. The history of tumours presumably of this type is that, if left alone or subjected to graduated pressure, they disappear.

(6) *Cartilaginous and Osseous Tumours.*

1022. These have been alleged to grow in connection with the gland, but they are so rare that they may almost be put out of account.

(7) *Cysts.*

1023. When any obstruction occurs in the course of a mammary duct the portion behind is liable to become cystic. As previously described (Sect. 1018), such cysts are common in all the connective tissue tumour diseases of the gland. They also occur where there is no such neoplasm.

---

[1] See "Animal Parasites."

There is a cyst tumour which forms, apparently in connection with a duct, close to the nipple. When cut into, its contents are seen to be either clear or turbid liquid or sometimes a colloid mass. Into this cyst grow occasionally one or more **warty papillary excrescences** often about half an inch in length. The stem of the excrescence is constituted of fibrous tissue and blood-vessels and its surface is covered with columnar epithelium. The cyst seems to resemble in some respects the papillary cystic tumour of the ovary (p. 434).

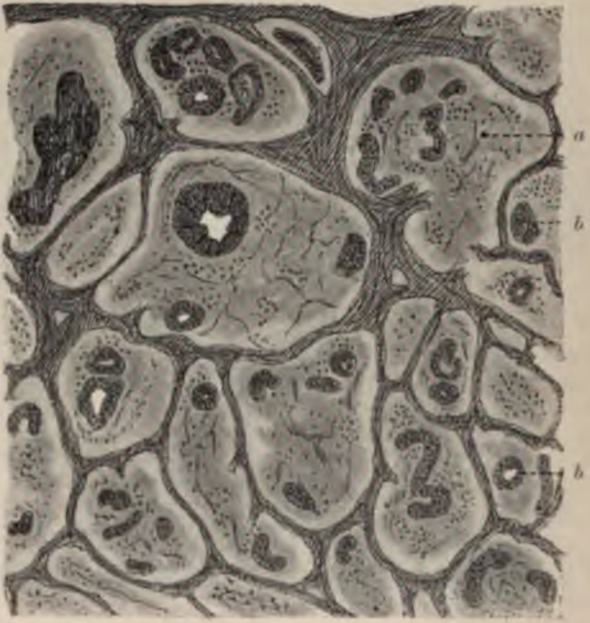


FIG. 510.—COLLOID TUMOUR OF THE MAMMA (×50 DIAMS.)

(*a*) Dilated gland elements filled with homogeneous colloid, and (*b*, *b*) desquamated epithelium of the acini (Picro-carmine and Farrants' Sol.)

As before remarked, cysts are very uncommon in mammary cancer. It may happen, however, that a cyst, perhaps about the size of a large hazel nut, develops immediately beneath the skin covering such a tumour. It will probably be found to contain deeply blood-stained fluid and to have a fibrous wall. Into its cavity a wart-like excrescence with dendritic extremities may project, as in the foregoing case. The tissue of the warty growth, however, differs from that in the simple cyst, in the fact that it consists of true cancer tissue alike with that of the main tumour mass, and that the layer of columnar epithelium present in the foregoing is absent in this. Whether or not the cyst originates in a duct is not quite clear. The blood-stained liquid in its interior would rather point to an injury of the part, with blood-extravasation and subsequent encapsuling of this, the cancer tissue making its way subsequently into the cavity.

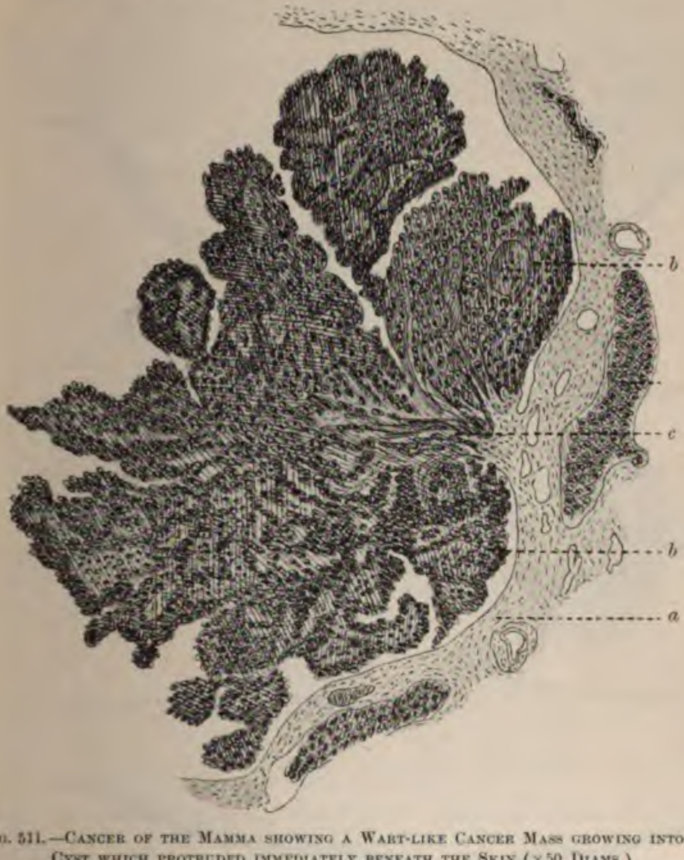


FIG. 511.—CANCER OF THE MAMMA SHOWING A WART-LIKE CANCER MASS GROWING INTO A CYST WHICH PROTRUDED IMMEDIATELY BENEATH THE SKIN (×50 DIAMS.)

(*a*) Part of the wall of the cyst; (*b*, *b*) the warty growth; (*c*) stem of same attached to the wall of the cyst (Logwood and Clarified).

MAMMARY ABSCESS.

The organisms of suppuration found in mammary abscess as in other abscesses are staphylococci and streptococci. These may be brought to the mamma by the blood-vessels, in which case they appear to be chiefly *staphylococci*. The abscess induced by them commences deeply. The cocci pass from the blood-vessels into the surrounding tissues. In the majority of cases, however, the staphylococcus appears to penetrate the gland along the course of the milk ducts, and escape into the cellular tissue from the acini. The *streptococci*, on the other

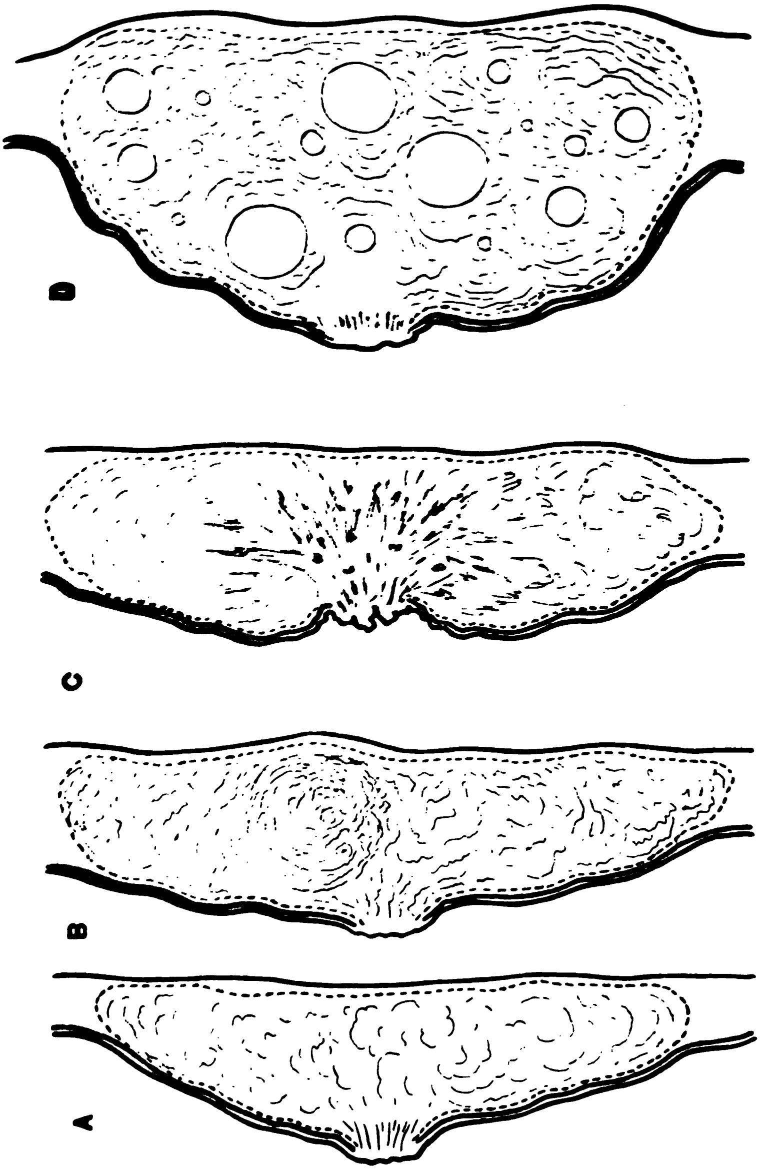


FIG. 512.—DIAGRAMMATIC SCHEMES OF THE NORMAL VIRGIN MAMMA, AND OF THE MOST IMPORTANT TUMOUR DISEASES OF THE MAMMA. EACH FIGURE REPRESENTS A LONGITUDINAL SECTION MADE THROUGH THE NIPPLE PERPENDICULAR TO THE SKIN.

(A) Normal virgin mamma; (B) fibrous tumour showing the new growth lying isolated in the gland; (C) old scirrhous cancer, showing the stellate processes, the retraction of the nipple, and the general atrophy of the gland; (D) cystic sarcoma, showing the relatively great size of the tumour, the widespread implication of the gland, and the cysts interspersed.

hand, it is said, ramify chiefly in the lymphatics, and superficially. They may gain entrance to the gland through a fissure in the skin.

TUBERCULAR MAMMA (see vol. i. p. 434).

DISEASES OF THE MALE BREAST.

1024. These are of comparative rarity. Sarcomata are perhaps more frequently met with than any others. Cancer of the rudimentary gland is rare; cancer of the skin over the mammary region may be mistaken for it. A colloid tumour of adenoma type is sometimes found.

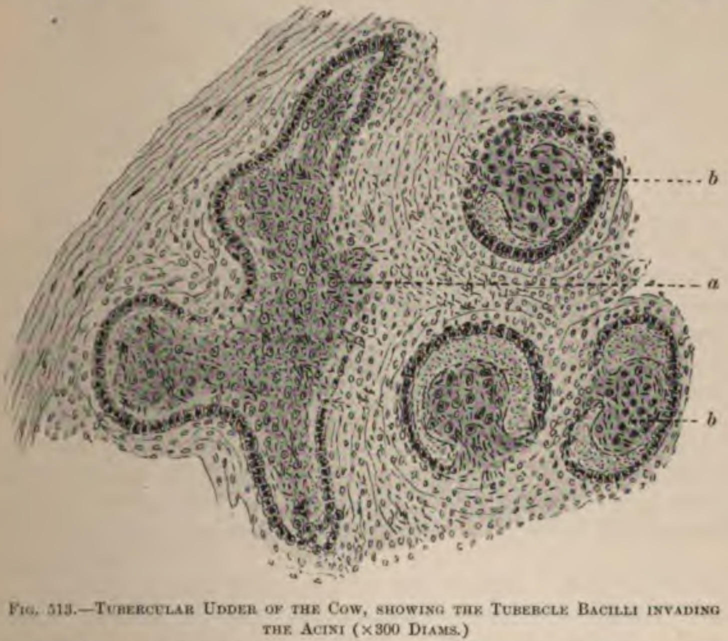


FIG. 513.—TUBERCULAR UDDER OF THE COW, SHOWING THE TUBERCLE BACILLI INVADING THE ACINI (×300 DIAMS.)

(*a*) Distended acinus filled with a homogeneous mass containing bacilli in abundance; (*b*, *b*) two other acini into which a tubercle growth containing bacilli is being pushed from the surrounding infiltrated stroma (Ziehl-Neelsen Stain).

Literature on Diseases of the Mammary Gland.—**Billroth:** Cyclop. of Obstet. and Gynec., ix. 1887, p. 1; *also*, Die Krankheiten der Brustdrüsen, 1880. **Birkett:** Diseases of the Breast, 1850; *see also*, Holmes' Syst. Surg. **Bryant** (Retracted Nipple): Brit. Med. Journ., 1866, ii. p. 635. **Bumm** (Inflammations of): Samml. klin. Vorträge, 1886, No. 282 (Gynäk., No. 79, p. 2045). **Coen:** Beitr. z. path. Anat. u. Physiol., Jena, 1887, ii. p. 83. **Creighton:** Physiology and Pathology of the Breast, 1878. **Dreyfuss:** Arch. f. path. Anat., cxiii. 1888, p. 535. **Gross:** Tumours of the Mammary Gland, 1880; *also*, American Syst. of Gynaec., ii. 1888, p. 197. **Handyside** (Polymastia in Brothers): Journ. Anat. and Physiol., vii. 1873, p. 56. **Kolessnikow** (Tubercle in Cow): Arch. f. path. Anat., lxx. 1877, p.

531. **Langhans** (Membrana Propria in Health and Disease): Arch. f. path. Anat., lviii. 1873, p. 132. **Leichtenstern** (Supernumerary): Arch. f. path. Anat., lxxiii. 1878, p. 222. **Leudet** (Good Synopsis of Literature): Arch. gén. de Méd., 1886, i. p. 18. **Murchison** (Supernumerary Nipples): Trans. Path. Soc. Lond., xvii. 1866, p. 426. **Paget** (Dis. of Mammary Areola): St. Barth. Hosp. Rep., x. 1874, p. 87. **Thin** (Duct Cancer): Trans. Path. Soc. Lond., xxxii. 1881, p. 218; *also* (Eczema of Nipple), Med. Times and Gaz., 1879, ii. p. 732. **Wickham**: Maladie de Paget, 1890.

CHAPTER LXXXVIII

DISEASES OF BONE AND JOINTS

STRUCTURAL SIGNIFICANCE OF BONE.

1025. BONE is essentially a calcified fibrous tissue. Its matrix can be resolved into a fibrous tissue not materially different from that existing in other parts of the body; and the bone corpuscle is to be regarded as a connective tissue corpuscle possessing the inherent power of throwing this out as a secretion from its protoplasm. Whether the lime and magnesia salts of bone matrix are secreted by the bone corpuscles or are merely thrown down in the matrix directly from the blood remains uncertain. In favour of the first view is the fact that the ossification of metastatic bone tumours follows the proliferation of their cells; while in justification of the second it may be recalled that the calcification of the matrix of hyaline cartilage which precedes true ossification follows the course of the penetrating blood-vessels.

Like the cornea, and probably also hyaline cartilage (Thin), the organic matrix of bone is laminated; and the laminæ are so arranged as to afford the greatest measure of support. Bone is provided with *blood-* and *lymph-vessels*, and with *nerves*, like any other connective tissue, so that, all things considered, the structural alterations ensuing within it as a result of disease, presumably, should correspond with those of any other dense fibrous tissue.

DEVELOPMENT OF BONE.

1026. There are said to be two methods whereby bones develop and grow—the *intra-cartilaginous* and the *intra-membranous*. The one is exemplified in the ossification of the cartilaginous rudiment of a long bone, the other in that of the flat bones of the skull and face and in periosteal ossification.

It may be questioned, however, whether there is any real difference in the two methods. Did the cartilage become directly transformed into bone there would be some show of reason for regarding the two methods as appreciably different. We know to the contrary that this is not the case. For the alterations within ossifying cartilage are mainly those which point to its absorption ; it is into the vacuities caused by its removal that the blood-vessels and osteoblasts penetrate, and it is in these that true ossification commences—an ossification which does not materially differ from that which is seen in periosteum. The bones, and the term is also applicable to their cartilaginous predecessors, have from the earliest times to bear strain. They also act as points of resistance to contractile tissues. Hence, from the first, it is necessary that they be composed of a compact substance. It seems therefore that the primitive cartilaginous condition of the bone is simply a means of affording a support sufficient for the time being. The cartilage no doubt acts as a convenient mould in which the future bone can be fashioned, but it is questionable whether, strictly speaking, it has anything to do with ossification. It must be borne in mind, however, that the two tissues, bone and cartilage, are closely related.

A long bone such as the os femoris or tibia is at first entirely cartilaginous, and presents in rough outline the shape which it will eventually assume. It is provided with a perichondrium, consisting like periosteum of a superficial and a deep layer. The superficial layer runs over the joint as its capsule, while the deep layer unites with the cartilage of the end of the bone, and does not proceed farther than the point which will mark the future junction of the epiphysis and the shaft. The same arrangement continues throughout adult life. The superficial layer of the perichondrium becomes that of the periosteum, and the deep layer is so modified as to constitute the deep or osteogenetic layer of this membrane. The cartilaginous phase in the history of the bone may be called the **first period** in its development.

Up till now the periosteal and cartilaginous rudiments of the bone are devoid of blood-vessels. A **second period** is ushered in by the **advent of vascularity** and by the penetration, in course of time, of the vascular twigs into the cartilaginous basis. Those which appear first show themselves in the *outer layer of perichondrium* and run parallel to the long axis of the bone. They are distributed primarily only to the diaphysis or shaft ; the *epiphyses* receive their blood-supply from the ramifications of the perforating or nutrient artery. From the main branches in the outer layer of the perichondrium smaller branches lead off into the *deep layer*.

While this vascularisation is taking place the deep layer of the perichondrium is showing unusual activity. The greater part of the original deep layer becomes converted into a lamina of bone (Birch). Some of its cells, however, remain free, and these proliferate actively so as to constitute a highly cellular basis to the otherwise fibrous investing membrane of the developing bone. This cellular layer goes by several names. It is known usually as the "osteogenetic layer." Virchow called it the "proliferative layer" ; Strelzoff the "osteoplastic layer" ; and Ranvier the "periosteal medulla." The cells of which it mainly consists are called **osteoblasts**. Each vessel of the deep layer and its surrounding osteoblasts is enveloped in a trabecular sheath of fibrous tissue, which later on becomes transformed into Sharpey's fibres. The osteoblasts now begin to throw out a matrix. It is fibrous at first, and within it canaliculi are to be seen. The osteoblasts are enclosed in little spaces formed by recesses or intervals between two adjacent fibrous laminæ. These spaces become the future lacunæ and the osteoblast the bone corpuscle.

The process so far is very much like that pursued in the formation of ordinary fibrous tissue. The deposition of bone salts next follows, whereby the periosteal lamellæ are transformed into bone matrix. The space surrounding the bone corpuscle is evidently lined with a cement substance which also suffers calcification, and, similarly, the canaliculi undergo conversion into regular tubes.

The bone thus formed is at first of the cancellous type. Intervals are found between its trabeculæ which enclose the periosteal vessels surrounded as above described; these are known as **Haversian spaces.** By the successive deposition of bone lamellæ on their interior these spaces become narrowed down to the capacity of Haversian canals, but each still retains its primitive blood-vessel derived from the periosteum. The periosteal bone thus constitutes a shell or crust to the cartilaginous part of the bone within.

The next event of importance is the **penetration of the nutritive artery** of the bone through the casing of periosteal bone, and subsequently its ramification throughout the cartilage in its interior. It pierces at a point about the middle of the shaft and makes its way towards the centre of the cartilage. Here it divides into two main branches, which pass upwards and downwards towards either end of the bone. Secondary branches are given off ultimately to the epiphyses. In some cases one set of branches anastomoses directly with another; while in other cases the terminal branches pass immediately into veins without the intervention of capillaries. A group of branches also runs in an arcuate fashion throughout the cartilage and unites with large venous stems beneath the periosteum (Maas, No. 92, xx. 1877, p. 723). Wherever arterial branches pass ossification commences.

Previous to the time when the nutritive artery penetrates, however, the cartilage in the interior has been preparing itself for ossification. This preparation, in fact, seems to commence with the appearance of the periosteal vessels, and consists mainly in a **calcification of the matrix of the cartilage** and a **multiplication of the cartilage cells.** Towards the epiphysial ends these cartilage cells split transversely to the long axis of the bone, and around each a capsule forms in the matrix. Rows of cartilage capsules thus result with their contained cells; and the rows lie of course in the long axis of the bone.

This calcification of the matrix is a very curious phenomenon, and is probably a measure for strengthening the cartilage during the time when it is being absorbed. Various explanations have been given of its cause, the most plausible being perhaps that it is due to the increasing vascularity of the embryo bone and its surroundings.

Into whatsoever parts the vessels spread they scoop out cavities, or at least their presence is accompanied by the scooping out of cavities, in the surrounding cartilage. The actual excavation seems, in part at least, to be effected through the agency of the cells which lie around the penetrating vessels. These enlarge and apply themselves to the cartilage about to be absorbed. They sometimes go by the name of **chondroclasts.** The cavities so scooped out are mostly elongated and arranged in rows in the long axis of the bone. Between them are the column- or pillar-like remains of the calcified cartilage.

It is within these spaces in the matrix that the cartilaginous ossification commences. The cells which envelop the twigs of blood-vessels are in great part of the nature of osteoblasts, derived most likely from the original periosteum. As the cartilage becomes absorbed the cartilage cells are liberated, and there is a difference of opinion as to whether they perish or become converted into osteoblasts. The former view is the one which finds most favour, namely, that they suffer disintegration and vanish, and that the bone-forming cells are in reality the periosteoblasts carried in by the blood-vessels from the enveloping membrane. Successive laminæ of bone are deposited within the absorption-spaces in the cartilage until these are nearly filled up. The remaining part of the space becomes a Haversian canal.

Then follows, curiously, a **stage of absorption.** The cartilage up till this time is entirely beset with cancellous bone. The modelling of the bone necessary to confer upon it its ultimate shape and to furnish the medullary canal now commences. This is effected mainly by the absorption of certain parts of the spongy bone just laid down. The manner in which the absorption is accomplished is afterwards explained

(p. 815). As the greater part of the endochondral bone is being removed to be replaced by the medulla, the surrounding periosteal crust becomes denser by the filling up of the cancellous vacuities within it, and thus comes to constitute the main bulk of the shaft.

The endochondral ossification proceeds more rapidly at certain parts than at others. These are named **points of ossification.** The small bones of the wrist and ankle, along with some others, possess only one such point of ossification. In a long bone, however, there are usually several, those at each end marking out the epiphyses. The various ossifying areas grow towards each other, and coalesce on the intervening cartilage being absorbed.

In the **ossification of a flat bone,** such as the parietal, the phenomena are very much alike with those seen in the development of bone from periosteum. Both are purely intramembranous, and take place without the occurrence of any substitution bone in the form of a calcified cartilage.

Growth of Bone.

1027. At the time of birth the bones in Man are partially ossified. In the long bones, however, the coalescence of the epiphyses and shaft is not effected until the growth of the bone is finished, and does not take place consequently till comparatively late in life. There remains a **bar of blue hyaline cartilage** between the bony centre of the epiphysis and the end of the shaft. It is by the production of successive relays of bone tissue at the diaphysial margin of this cartilaginous plate that the bone increases in length. Experiment seems to disprove the supposition that the bone lengthens by interstitial increment. Pegs inserted into the shaft of a growing bone do not become further separated as the bone increases in length (Hales, Hunter, etc.).

The epiphysial bar of cartilage, according to Busch (No. 43, xxi. 1884, p. 213), is connected exclusively with the ossification of the shaft; and this is borne out by the fact that the cartilage cells arrange themselves in rows only on the side adjacent to the distal end of the bone. The epiphysis seems to ossify separately, and chiefly upon its arthrodial aspect. Its ossification even here is never complete; parts of the original cartilage are left as the **permanent articular cartilages.** The periosteum reaches only to the junction of epiphysis and shaft. It has nothing to do with epiphysial ossification.

Between the bar of blue hyaline cartilage and the bony shaft there is a line which to the naked eye is marked off from surrounding parts by its unusually great vascularity and consequent redness. It is known as the **epiphysial line,** because it separates the epiphysis from the remainder of the bone. Within it are to be seen the absorption spaces tunnelled out in the cartilaginous bar of the epiphysis. These spaces contain blood-vessels surrounded by osteoblasts, and the osteoblasts are engaged in depositing layer upon layer of bone tissue within them. As the cartilage is absorbed new cartilage is deposited in the epiphysis, and this suffers a like fate. The epiphysis thus continues to furnish a support sufficient for temporary purposes, which also serves as a mould in which the future bone may be cast. As the bone increases in length the epiphysis is pushed farther and farther away from the centre of the shaft until the time when a fusion of the epiphysial and diaphysial bone arrives. When this fusion is completed growth of the bone ceases.

If the epiphysis be removed along with the epiphysial line, growth at that end of the bone is arrested. *If the epiphysial line be left*, it is probable, as Humphry states (No. 34, xlv. 1862), that the growth of the bone will be completely or nearly alike with that on the opposite side of the body.

It has been asserted, however, that long bones have, in very rare cases, been observed to grow after union of the epiphysis with the shaft, and sometimes this has occurred unilaterally. The explanation is said to be that new bone is laid down under the articular cartilages.

Articular cartilages are usually held to subserve simply a mechanical and passive purpose, namely, in diffusing pressure. As pointed out, however, by Ollier (quoted by Busch, No. 43, xxi. 1884, p. 213), Kölliker (*Ibid.*), Sharpey (No. 566, pt. ii. 5th ed. p. 158), Tomes and De Morgan (No. 65, cxliii. pt. i. 1853, p. 109), and Ogston (No. 5, x. 1875, p. 49), and as confirmed by Busch (No. 43, xxi. 1884, p. 212), it is likely that they also to some extent are concerned with the production of new bone, and that they thus repair the loss which is always occurring in the articular extremities from pressure. It is conceivable that by an exaggeration of this function an amount of new bone might be thrown out sufficient to occasion perceptible elongation of the limb.

The growth of the bone in breadth is accomplished entirely through the mediation of the periosteum. Successive layers are deposited from it *pari passu* with the absorption of the older layers from within.

Literature on Structure, Growth, and Development of Bone.—**Birch**: Journ. of Physiol., 1879-80, p. 360. **Busch**: Berl. klin. Wochnschr., xxi. 1884, p. 212. **v. Ebner**: Sitzungsb. d. k. Akad. Wien., lxxii. Ab. 3, H. 1-5, 1875, p. 49. **Humphry**: Treatise on the Human Skeleton, 1858. **Kassowitz**: Die normale Ossification, 1881. **Klein**: Atlas of Histology. **Kölliker**: Verhandl. d. physik. med. Gesellsch., Würzburg, iv. 1873, p. 46. **Maas**: Arch. f. klin. Chir., xx. 1877, p. 714. **Ogston**: Journ. Anat. and Physiol., x. 1875, p. 49. **Rutherford**: Textbook of Physiol., pt. i. 1880, p. 94. **Schäfer**: Quart. Journ. Mic. Sc., xviii. 1878, p. 132; *see also* the various text-books on Histology and Physiology.

ABSORPTION OF BONE.

1028. In the modelling of a bone and in the formation of the medullary cavity, as previously explained (p. 813), part of the trabecular bone which is laid down in the first instance, and which has served a temporary purpose in affording support, is absorbed. At the edge of the bone-trabeculæ under such circumstances little cup-like erosions are seen in great abundance. They are sharply punched out of the bone matrix and at first are mere microscopic objects. Later on, however, they become confluent, and are converted by this means into excavations perceptible with unaided vision. They give to the outside of the piece of bone a peculiarly worm-eaten appearance, and ultimately effect its complete disintegration. They were first described by Howship, and are named after him **Howship's lacunæ or foveolæ.**

They are also found in bone being absorbed from senile decay or from the pressure of tumours such as aneurisms. In different forms of osteitis they are also met with, in caries, and in the solution of sequestra, ivory pegs, etc. In fact, whenever bone is being absorbed they are more or less prevalent at its margin.

Within the space is contained a giant-cell, or it may be a quantity of granulation tissue. The giant-cells are most likely over-nourished bone corpuscles which have been liberated from the part, or it may be over-nourished cells derived from surrounding fibrous tissue. That they are not all bone cells is proved by the fact that identical giant-cells soon come to surround and to be applied to almost any organic substance placed, it may be, in a tissue far removed from a bone. Attention has already been directed to the bodies of this kind which envelop the keratode framework of sponge (see Fig. 102) when it is embedded in a living tissue.

Kölliker (No. 562) takes the view that it is through the agency of these giant-cells that the bone is absorbed. He holds that they assimilate the organic part of the bone and utilise it as pabulum, while, at the same time, they bring about a solution of the lime salts. He accordingly names these giant-cells **osteoclasts** or **osteophagi** (Fig. 515). This view, in the main, is largely accepted at the present day, but that the giant-cells are the sole living agents in effecting this digestion of bone is held by many to be too narrow a statement of the case.

The notion that it is the living cells around the part which cause the solution was first broached by Tomes and De Morgan (No. 65, cxliii. pt. i. 1853, p. 129). They found numerous absorption spaces filled with **granulation tissue** in the bone protruding from an unhealed stump and which was being absorbed. The granulation cells were applied to the walls of the spaces in such a manner as to convey the impression that they were the agents employed in the excavation. In accordance with this observation it is held by Billroth (No. 92, ii. 1862, p. 126), Ziegler (No. 13, lxxiii. 1878, p. 367), Pommer (No. 13, xcii. 1883, p. 296), Ochotin (No. 13, cxxiv. 1891, p. 97), and many others, that young living cells of almost any kind may similarly take on the properties of osteophagi. As Ziegler remarks, there are many inflammations of bone in which the compact tissue becomes rarefied, and in which polynucleated giant-cells are entirely absent; and yet the parts which are being absorbed present evidence of lacunar dissolution in the highest degree. In tumours of bone also which are not of a giant-cell type some of the best examples of lacunar absorption are to be found. The spaces are filled with the ordinary cells which prevail throughout the tumour.

Billroth supposed (No. 92, ii. 1862, p. 126) that the lime salts were rendered soluble by the granulation tissue secreting *an acid*; Schmidt and Stadeler found lactic acid in osteoporotic bones, and Billroth held that it is this which effects the solution. This solution-by-an-acid theory has been accepted by Kolliker, Rustizky, and Pommer. It is usually maintained that the organic part of the bone suffers a species of digestion.

Still, although the absorption of the effete tissue by the living elements in its neighbourhood seems to be incontestable in most cases, it must be borne in mind that the mere **pressure** from undue vascularity may, under certain circumstances, induce an atrophy of the bone matrix, just as we see happen to the liver cells in cyanotic atrophy of the liver, or in other like diseases.

Virchow early adopted this view and supposed that the absorption commenced in the bone lacunae. Volkmann (No. 115, ii. Ab. II. p. 234 *et seq.*) regarded the absorption as the effect of undue vascularity beginning in the Haversian canals. These become dilated so as to constitute spaces of irregular shape. They increase in size and become confluent, whereby an osteoporotic condition results. This, he says, accounts for the swollen cancellous state of the heads of long bones in joint-disease, and it is also the means whereby the anfractuosities of the ends of a broken bone are rounded off.

This view, it may be mentioned, is strenuously opposed by some authorities at the present day. Nevertheless it is likely that it contains a large element of truth. Rustizky (No. 13, lix. 1874, p. 202) and Ribbert (No. 13, lxxx. 1880, p. 436) so far support Volkmann's view in that they believe in bone being absorbed without the agency of giant-cells. They state that where it is being destroyed by pressure the presence of giant-cells is inconstant.

In the hollowing out of the medulla of a long bone giant-cells are present in considerable abundance, and it is stated by Maas (No. 92, xx. 1877, p. 729) that they are clustered chiefly round the small veins and venous capillaries. Still it must be remembered that the bone corpuscles in being liberated tend to swell up and to excavate Howship's lacunæ in the matrix, thus occasioning an appearance which might be readily misinterpreted. It would be rash to conclude that in all cases there is an application of the giant-cells to the absorbing bone with the intent of their effecting its absorption.

Literature on Bone Absorption.—**Billroth**: Arch. f. klin. Chir., ii. 1862, p. 118. **Cameron**: Glasg. Med. Journ., xvi. 1881, p. 112. **Coats**: Glasg. Med. Journ., vi. 1874, p. 321. **Hale White**: Guy's Hosp. Rep., 1885, p. 6. **Kölliker**: Die normale Resorption d. Knochengewebes, etc., 1873. **Macewen**: Annals of Surgery, 1887. **Morison**: Edin. Med. Journ., xix. 1873, p. 305. **Pommer**: Arch. f. path. Anat., xcii. 1883, p. 296. **Rustizky**: Arch. f. path. Anat., lix. 1874, p. 202. **Wegner**: Arch. f. path. Anat., lvi. 1872, p. 523.

BONE-GRAFTING.

1029. This subject has already been incidentally referred to (vol. i. p. 308). It may be advantageous to discuss it here a little more in detail.

There does not seem to be much doubt that living bone taken from the same species is capable of retaining its vitality when introduced into the tissues of a new host.

Macewen (No. 149, xxxii. 1881, p. 238) relates the following experiment in support of this view: A boy aged three years was placed under his care in a weak and emaciated condition from suppuration connected with a necrosis of the right humerus. Fourteen ounces of fœtid pus were evacuated by puncture from an abscess around the bone. The shaft of the humerus was found to be totally necrosed and had separated from its epiphysial junction with the head. Over two-thirds of the shaft were eventually removed. Suppuration continued diffuse for a fortnight, and afterwards gradually diminished. A tapering portion of bone was left attached to the head. So far as could be made out the periosteum opposite the sinuses was destroyed, and its place taken by granulation tissue. The wounds healed and the spicule of bone continued to grow for a little, but eventually ceased to do so.

In one year and three months from the time of resection of the bone the two ends were separate as before. The upper spicular end was now cut down upon and found to be cartilaginous. The cartilaginous part was excised, and a sulcus about 2 inches in length was made in a downward direction through the muscles. Two wedges of bone were removed from the tibiæ of a patient six years of age with anterior tibial curves, and were chopped into small fragments. They were then deposited in the sulcus above described. The whole operation was conducted antiseptically, and the time occupied in removing the wedges and placing them in their new position was from two to three minutes. The wound healed without suppurating. In a month afterwards a piece of bone 1 inch in length and, as nearly as could be measured, ¾ inch in thickness was found firmly attached to the upper fragment of the shaft.

A similar transplantation was made on two other occasions, the adjacent end or ends of the bones being refreshed at each operation, with the result that the parts adhered and formed a solid rod—a new shaft.

Poncet (quoted by Ochotin, No. 13, cxxiv. 1891, p. 98) relates an almost identical case of interhuman transplantation: A boy aged eleven years had lost the entire shaft of the femur through osteomyelitis. The dead bone was removed, and fifteen days afterwards, while the wound was granulating, pieces of chopped-up bone 3-4 mm. thick and 7-8 mm. long from the body of a dead newly-born child were introduced among the granulations. A complete ossification of the granulating mass followed with reimbursement of the shaft. The bone, however, remained about 3 cm. shorter than that on the opposite side.

There is, however, as yet a difference of opinion as to whether in such operations the grafts actually live or whether they simply act as a mould for the construction of new bone. Macewen is an ardent disciple of the former doctrine, and certainly his results seem to warrant his conclusions.

The researches of Adamkiewicz (No. 563, xxvi. 1889, p. 123, referred to by Ochotin) also support the vital theory of bone grafts. The grafts, he says, are united to the neighbouring bone, firstly, by fibrous tissue. This, if not too extensive, becomes rapidly ossified, so that in a few months there is a continuous bony mass with intercommunicating blood-vessels. A new periosteum seems to be deposited on the surface.

Ollier, however, even in one of his latest utterances on the subject (No. 4, i. 1889, p. 167), is not persuaded that the grafts of themselves produce the new bone, but inclines to believe rather that they confer bone-forming properties upon the periosteum, which for the time being it had lost. This, he says, is the only principle on which he can understand the new formation of a shaft.

There is much doubt as yet whether bone can be successfully transplanted from an animal of a species different from the recipient host—that is to say, whether a successful heteroplastic graft is a possibility. Autoplastic and homoplastic grafts (Ollier)—that is to say, those taken respectively from the same individual or from an individual of the same species—have both been found to be possibilities, but the heteroplastic operation is as yet a matter of doubtful feasibility.

Patterson (No. 59, 1878, ii. p. 539) attempted to transplant a piece of dog's bone into a vacuity between the ends of a pseudo-arthrosis of the forearm. The graft seemed to contract adhesions, but was eventually thrown out. Macewen has met with a like result. Poncet (quoted by Ollier, No. 4, i. 1889, p. 167) has apparently been more successful. He transplanted pieces of bone from the fœtal rabbit and kid into a vacuity in a human bone, and found that they were soon enveloped in a casing of new bone. Ollier, however, holds to it that they were simply absorbed, but admits that they may have stimulated the parts locally. On this account he does not think that heteroplastic growths are entirely useless.

TRANSPLANTATION OF DEAD BONE.

1030. Ochotin (No. 13, cxxiv. 1891, p. 97) has made some experiments on the fate of dead bone when introduced into the midst of one which is living. His researches were made on rabbits, and consisted in boring a hole through a long bone down to the medulla and introducing a peg of bone or ivory. He recommends bone from a young ox on account of its being most readily absorbed. The operation in all cases was conducted antiseptically. The animals were killed at periods of 7, 12, 18, 32, and 42 days, the parts hardened for three days in alcohol, decalcined in an 8-10 per cent solution of nitric acid, and soaked in water for twenty-four hours. The hardening was completed by further three days' immersion in alcohol.

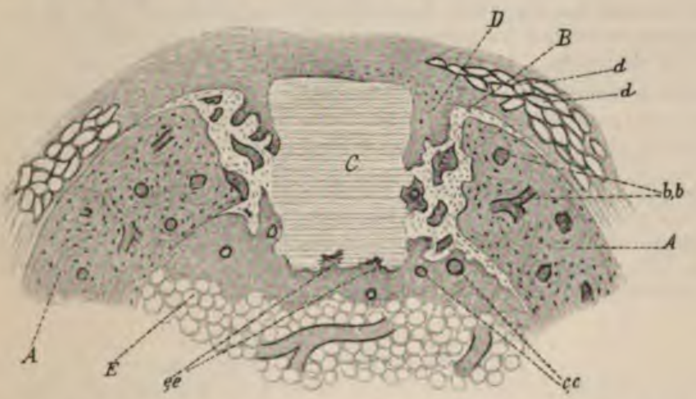


FIG. 514.—IMPLANTATION OF A PIECE OF IVORY INTO FEMUR OF RABBIT. APPEARANCE OF TRANSVERSE SECTION AFTER THIRTY-TWO DAYS (×52 DIAMS.)

(A) Part of circumference of shaft; (B) newly formed bone; (C) the ivory; (D) capsule surrounding the ivory; (E) bone medulla.

After seven days the peg was found to be encapsuled by fibrous tissue, and was firmly fixed in the aperture. The medullary cavity at the inner extremity of the peg was widened by thinning of the bone walls, but no particular change was found in the piece of dead bone itself. A few erosions were perceptible after twelve days. In from thirty-two to forty-two days the capsule intervening between the dead and living bone had here and there vanished. The piece of dead bone appeared to have coalesced with the edge of that which was living, and new bone was thrown out between the two in the form of trabeculæ. The undue space in the medulla had now disappeared, and the medulla came again to be in immediate contact with the peg, on whose surface there were many erosions. He says that the new bone was derived not only from the periosteum, but also from the bone itself. The corpuscles of the latter had enlarged and divided. The Haversian canals at the end of the living bone had widened and become filled with osteoblasts.

He remarks, however (p. 107), that there never was any *organised* connection between the dead and the living parts. The dead bone plays simply a passive rôle, and suffers progressive absorption.

TRANSPLANTATION OF PERIOSTEUM.

1031. Although somewhat doubtful about the inherent powers of bone to reproduce itself in a graft, Ollier (No. 4, i. 1889, p. 166) is a firm believer in periosteum as a bone-forming agent under like circumstances. He has himself successfully transplanted it; and holds that any merit which may have attended grafting of bone is due to its having retained its periosteum. Macewen (No. 149, xxxii. 1881, p. 232) maintained formerly that the fragments of bone used as grafts should include the whole of the osseous elements. Later on (No. 564, 1887, p. 618) he found that "the preservation of the periosteum is not an essential to the success of the graft."

Buchholz (No. 13, xxvi. 1863, p. 78) says that, when periosteum is transplanted, its cells proliferate. One part of the mass becomes cartilaginous, but the bone resulting from its transplantation does not necessarily pass through the cartilaginous stage. The periosteum of the flat bones of the skull, he says, does not seem to have the same osteogenetic powers as that taken from the hollow bones.

TRANSPLANTATION OF MEDULLA.

1032. The bone medulla appears to have a certain osteogenetic power. When transplanted autogenetically the graft takes root and throws out bone. It is unsuccessful when the graft is carried from one animal to another even of the same species. Thus Ollier (No. 561, i. p. 117) did not succeed in a single instance out of a series of fifty experiments where the transfer was to a new host; while Maas (No. 92, xx. 1877, p. 708) and Goujon (No. 200, vi. 1869, p. 399) seem to have had a like experience. Baikow (No. 50, viii. 1870, p. 371) also found that the graft did not throw out bone when the transfer was crossed, but, when confined to a single animal, bone was generated in fourteen out of twenty-eight instances.

Bruns (No. 92, xxvi. 1881, p. 661) was even more successful than Baikow. In twelve experiments out of a series of nineteen where autoplastic transplantation was made into the soft tissues of a single host, the graft lived and became ossified. He employed dogs, and from their long bones cut out cylinders of marrow which he transferred to the soft tissues of the chest or back. In from ten to twelve days there was a copious proliferation of young cells mostly of a spindle shape. Ossification appeared to be both intra-membranous and intra-cartilaginous, the former predominating. In the case of the cartilaginous ossification the cartilage matrix, he says, becomes calcified, and the cartilage cells are converted directly into bone corpuscles. He states, curiously, that when the medulla is removed from the cancellous tissue of an epiphysis along with the trabeculæ of bone, it has not the slightest inclination to ossify, but, on the contrary, becomes absorbed through the agency of a bevy of giant-cells which encompass it.

Literature on Regeneration of Bone.—**v. Berg**: Untersuch. üb. Knochenregeneration unter antiseptischem Verbande, 1878. **Bidder**: Arch. f. exper. Path. u. Pharmakol., i. 1873, p. 248; *also*, Arch. f. klin. Chir., xxii. 1878, p. 155. **Buchholz**: Arch. f. path. Anat., xxvi. 1863, p. 78. **Hein** (After Fracture): Arch. f. path. Anat., xv. 1858, p. 1. **Hopkins** (Organisation and Absorption, Dead Sterilised Bone): J. Am. M. Ass., Chicago, xiv. 1890, p. 505. **Humphry**: Med.-Chir. Trans., Lond., vols. xxxvi., xli., xliv., and xlv.; *also*, Journ. Anat. and Physiol., xiii. 1878, p. 86. **Krafft**: Ziegler and Nauwerk's Beiträge z. path. Anat., i. 1886, p. 85. **Maas**: Arch. f. klin. Chir., xx. 1877, p. 708. **Macewen**: Proceed. Roy. Soc., Lond., xxxii. 1881, p. 232; *also*, Heath's Dictionary of Pract. Surg., i. 1887, p. 617. **Neve**: Edin. Med. Journ., xxxv. 1889-90, p. 719. **Ochotin**: Arch. f. path. Anat., cxxiv. 1891, p. 97. **Ogston**: Journ. Anat. and Physiol., xii. 1877, p. 503. **Ollier**: Gaz. hebd. de méd., v. 1858, p. 572 *et seq.*; *also*, Journ. de la physiol., ii. 1859, p. 1 *et seq.*; *also*, *Ibid.*, Arch. de physiol. norm. et path., v. 1873, p. 5; *also* (Bone Graft), Arch. de physiol. norm. et path., i. 1889, p. 166; *also*, Traité de la regénération des os, 1867. **Phelps**: N. Y. Med. Rec., xxxix. 1891, p. 221. **Senn** (Healing of Aseptic Bone Cavities by Implantation of Antiseptic Decalcified Bone): J. Nat. Ass. Railway Surg., Fort Wayne, ii. 1889-90, p. 263. **Virchow**: Arch. f. path. Anat., v. 1852, p. 409. **Volkmann**: Arch. f. path. Anat., xxiv. 1862, p. 512; *also*, Centralbl. f. d. med. Wissensch., viii. 1870, p. 129. **Ziegler**: Arch. f. path. Anat., lxxiii. 1878, p. 355.

HEALING OF FRACTURED BONE.

1033. A fractured bone seems to unite in exactly the same manner whether the fracture be simple or compound. The opposite has often been asserted, but it seems now to be pretty generally admitted that there is no difference provided the wound is kept aseptic. If it becomes septic inflammatory changes modify the process of union very considerably.

It has also been alleged that the mode of union of fractured bones in animals differs from that in Man. This seems to be equally insupportable.

The parts concerned in the repair of the bone are the periosteum, possibly the ends of the bone itself, and the surrounding connective tissues. The bone medulla has been held to furnish some of the reparative materials, but this still remains doubtful.

A fractured bone seems to repair itself by a repetition of what has been described (p. 812) as the process of ossification in a long bone.

As a result of the laceration of the parts at the point of disunion, more or less blood is effused from the wounded blood-vessels and coagulates. In from twenty to thirty hours after the fracture has occurred the surrounding torn remnants of periosteum, as well as that covering the ends of the bone, are seen to be proliferating. The periosteum at these parts becomes filled with new cells derived from those already within it. The blood-vessels, probably from the pressure exerted upon them by the clots, and it may be from the unusual position of the bone, become turgid, and some effusion of liquid and solid contents takes place through their walls—that is to say, a certain amount of inflammatory reaction occurs at the fractured ends. This, however, never goes very far if the wound remains aseptic.

The surrounding tissues are overstimulated and proliferate somewhat like the periosteum. In course of time the blood begins to be absorbed, and its place is taken by a progeny of new cells derived mainly from the periosteum. The connective tissues of neighbouring parts by proliferating afford a capsule to the enclosed embryonic materials (Hein, No. 13, xv. 1858, p. 8). This capsule shortly after being formed thickens on its inner aspect, and affords the same protection to internal parts as the perichondrium of a fœtal bone.

The cells which fill up the interval between the fractured ends and which have primarily been derived from the periosteum now take on a cartilage type and throw out a little cartilaginous matrix. It is within this cartilage that the future bone is moulded, and the history of events is identical with what follows the penetration of the *arteria nutritia* into the cartilage of the shaft of a fœtal bone. Several small vessels push their way from outside into the embryonic cartilage filling the vacuity. They are for the most part simply offshoots from those in the periosteum. Wherever they are driven inwards the cartilage becomes absorbed, and it is in the resulting space that ossification proceeds. The osteoblasts are probably in the main carried inwards by the vessels as in normal endochondral bone formation. The bone at first is of a cancellous type.

Not only does this go on between the ends of the bone; the reparative cells also fill the medullary cavity for a certain distance at each end, and ossification proceeds there as in other parts. The continuity of the medullary cavity is thus at first interrupted, and any yellow marrow which is lying at the seat of fracture is removed. There is great danger of fat embolism occurring during the absorption of its oil.

The fractured ends are now united by a cartilaginous basis permeated by trabeculæ of bone. Ossification begins outside, so that there may be a shell of cancellous bone at the periphery while the interior is as yet purely cartilaginous.

The ragged fractured ends of the bone become vascular, and their compact tissue opened out. There is every reason to believe that they act as centres of ossification, and that vessels are projected from them into the primary cartilaginous mass.

The term **callus** (*callus*, *callum*, a hard skin) is an old one applied to the reparative bond of union between the fractured ends. That which consists of the above cartilage and cancellous bone, and which we shall see subserves merely a temporary purpose, is known as **provisional callus,** while that which permanently unites the extremities is called **definitive callus.** Sometimes the outer bony crust of the provisional callus is known as the **external callus,** while that which lies within and is more purely cartilaginous is named **internal callus.**

So far, it will be noticed, there is a close resemblance in the method of repair of the injury to that which occurs in normal ossification. The analogy is carried still further in that the cancellous bone in the interior becomes hollowed out so as to reproduce the medullary cavity, while that which lies externally becomes strengthened by the addition to its substance of superimposed laminæ. Giant-cells show themselves at the parts which are being absorbed. In course of time the continuity of the medullary cavity is re-established, and it becomes filled at the fractured point with *red* marrow. If the bones override, the callus which has filled up the end of the cavity in the bone is not entirely scooped out. Part of it remains, and by condensation aids in affording support (Maas, No. 92, xx. 1877, p. 752). All gross irregularities on the outer aspect of the callus are removed by a method of absorption alike with that which takes place in the interior.

Finally, the connective tissue capsule contracts and constitutes the superficial layer of a new periosteum (Billroth, No. 92, vi. 1865, p. 719). The deep layer is probably derived from the original periosteoblasts.

Simple Fracture with Dislocation.

1034. In the *Dislocatio ad axin*, according to Hein (No. 13, xv. 1858, p. 20), more callus seems to form on the concave than on the convex side.

In the *Dislocatio ad latus*, by which is meant a dislocation so far to the side, but where the bones do not override, the amount of swelling and inflammation is greater than in the foregoing. The re-establishment of the continuity of the medullary cavity is effected by the absorption of the adjacent parts of the bone where they are in contact. This takes place at the time when the absorption of the provisional callus is proceeding.

In the *Dislocatio ad longitudinem*, in which the ends of the bone override, healing goes on very much as in the foregoing, but he says he has not had an opportunity of observing the reinstatement of the medullary cavity.

In the case of a combination of the last two, where the dislocation to the side is considerable, bone may still unite the two ends. The hollowing out of the medullary cavity naturally becomes a matter of difficulty; it is doubtful whether it ever occurs. Both in this and in the other forms, where the displacement is great, the hard permanent callus does not stretch from the fractured tip of the bone, but from the free surfaces of the shaft some distance above and below the fracture. The jagged ends of the bone become absorbed.

NECROSIS OF BONE.

1035. Death of a bone or of a piece of it may of course arise from a multitude of causes. It is not usually so much the result of disease of the bone itself as of the withdrawal of the blood-supply. The following are the terms in use to designate degrees of necroses :—

(1) **Peripheral necrosis or an exfoliation,** where one or more of the superficial lamellæ die. The part when cast off is known as a *sequestrum* (*sequestrare*, to sever or give up).

(2) **Central necrosis or necrosis interna,** where a portion of the spongy bone in the interior dies.

(3) **Total necrosis,** where the bone perishes throughout its entire thickness.

(4) **Necrosis of an entire bone.**

(5) **Multiple necrosis,** occurring in certain dyscrasiæ.

Dead pieces of bone frequently become partially absorbed. At other times they become encapsuled by new bone thrown out round about them. An entire shaft may thus be enclosed in a casing of new bone and remain in this position for years, the new bone fulfilling the function of that which has died. Should the necrosis occur in the middle of a shaft, a pseudo-arthrosis may form between the ends of the bone after its removal.

Inhalation of the fumes of **phosphorus** gives rise to a form of periosteitis which ends in necrosis of the bone. The bones of the jaws are most liable to be affected.

PERIOSTEITIS.

1036. The periosteum, being a vascular membrane, is of course liable to inflammation, sometimes the result of injury but more frequently associated with the strumous or syphilitic diathesis. Suppurative periosteitis is often of a septic nature. Inflammatory affections of bone and its membranes are also more common in youth than in adolescence or old age.

Simple Periosteitis.—In that, for instance, resulting from a blow upon the shin, the membrane becomes hyperæmic, its deep layer proliferates, and inflammatory products infiltrate its substance. They tend to accumulate in its deep layer; there is comparatively little exudation between the bone and the membrane. The bone, if affected at all, suffers only superficially. The effusion may be expected to disappear after the acute hyperæmia has subsided, and little trace of the affection remains. In some cases a ridge of bone is left, from the accumulated osteoblasts having ossified. This is a common affection in horses, the ridge being known as a **splint.**

Suppurative Variety.—A much more serious disease is where the effusion accumulates between the bone and its enveloping membrane and suppurates. This suppurative form of the disease is commmonest in youth and mostly in boys. The humerus is a bone which, for some unknown reason, suffers frequently from it. The membrane is stripped off from the bone and is converted into an abscess sac. An entire shaft may thus be laid bare. The pus is of a greenish colour and teems with the *organisms of suppuration* (*q.v.*), chiefly with staphylococcus pyogenes aureus. The shaft usually dies and separates from its epiphyses. The epiphyses may still nevertheless retain their vitality. There is great danger of the affection ending fatally from septicæmia and pyæmia.

The necrosis need not be total; it may implicate only the superficial strata of bone, in which case an exfoliation takes place through the opening in the abscess sac.

Hæmorrhagic Variety. — Periosteitis sometimes assumes a hæmorrhagic type, in which case blood is found in the sac. The periosteum may be completely separated from the shaft of the femur, and, in place of pus, the sac is filled with a huge firm clot of blood. There may appear to be an entire absence of suppuration.

Chronic Fibrous Periosteitis.—Most of the foregoing varieties run an acute course. It happens, however, that many instances of periosteitis are chronic and are accompanied by great fibrous thickening of the membrane. The term **periosteitis fibrosa** is usually applied to the affection. In the acute varieties the cellular part of the effusion is derived chiefly from the deep layer of the periosteum and it may be from the superficial layers of bone (Billroth). In the chronic form the superficial laminæ of bone are always involved. The bone assumes a thickened appearance from the fibrous excess around it. Part of this ossifies, so that when the bone is macerated irregular outgrowths of bone are found adhering to the shaft. These go by the name of **osteophytes** (φυτόν, a plant), from the somewhat plant-like aspect they present. So great may the thickening around the bone become that the limb assumes almost the aspect of an elephantiasis.

Periosteitis Albuminosa.—This is a peculiar disease observed by Ollier (description through Poncet, No. 251, 1874, Nos. ix. and xii.). Usually there is coexistent osteitis, and it may be osteomyelitis, most likely with a sinus in the bone from which yellowish granulations protrude. From the sinus there stream out large quantities of viscid albuminous liquid with little if any pus in it. The liquid, according to Schlange (No. 92, xxxvi. 1887, p. 97), sometimes becomes encapsuled in the soft parts round the bone. It has a close resemblance to synovia, but staphylococcus pyogenes aureus is abundant in it. According to Kastus and Liebermann (referred to by Schlange, *loc. cit.* p. 112), it contains albumin, paralbumin, metalbumin, phosphates, carbonates, and grape-sugar. Poncet says that when the liquid is allowed to settle it separates into three layers. The lowest is a compact mass of fibrinous flakes, corpuscles, etc.; the middle is an albuminous liquid, which, by coagulating on cooling, resolves itself into fibrin and serum; while the highest stratum is composed mainly of oil globules evidently derived from the bone. The liquid keeps for long without putrefying; its origin is as yet doubtful.

Syphilitic Periosteitis (see Sect. 1045).

Literature on Periosteitis.—**Billroth** (Growth, Periosteitis, and Caries): Arch. f. klin. Chir., vi. 1865, p. 712. **Dent**: Med.-Chir. Trans., Lond., xlvi. 1881, p. 307. **Duplay** (Albuminous): Arch. gén. de méd., cxlvi. 1880, p. 728. **Eberth**: Arch. f. path. Anat., lxv. 1875, p. 341. **Legiehn**: Ueb. d. sogenannte Periosteitis u. Osteitis albuminosa, 1890. **Roser** (Albuminous): Centralbl. f. Chir., xiv. 1887, p. 929. **Schlange** (Albuminous): Arch. f. klin. Chir., xxxvi. 1887, p. 97. **Smith** (Hæmorrhagic): Trans. Path. Soc. Lond., xxvii. 1875-76, p. 219. **Tubby** (Acute Infective): Guy's Hosp. Rep., xxxii. 1890, p. 77.

OSTEITIS.

1037. The communication between the blood-vessels of the periosteum and those of the bone is so close that it has been denied (*e.g.* Meyer and Billroth) that an inflammation of bone can occur apart from the periosteum or medulla participating in it. Volkmann, however (No. 115, ii. Ab. II.), takes a different view, and believes in the autonomy of the bone tissue in this respect.

When a bone inflames, be the affection complicated with periosteitis and osteomyelitis or not, its vessels become turgid, and inflammatory blood-constituents exude from them as in soft parts. The vessels are bound down by the rigid walls of the Haversian canals, but soon these yield and become distended. The bone laminæ are disintegrated and absorbed so that a dense bone is converted into one composed of trabecular bone tissue—it suffers, in fact, from what is termed **rarefying osteitis.**[1] Owing to the distension of the vessels and the inflammatory infiltration of the parts the bone may assume a blown-out appearance, and, from the loss of its dense matrix, can be readily cut into.

After the inflammation has subsided the regenerative powers of the bone begin to assert themselves with unusual vigour, and new bone is laid down in the cancellous spaces (Fig. 515). The result is that the part which has been the seat of the inflammation becomes extremely dense. An **osteosclerosis,** as it is called, follows upon it.

It may happen, however, that the parts suppurate and an abscess forms in the bone substance. This is unusual. The abscess may evacute itself externally, but more often is surrounded and pent up by a layer of sclerous bone tissue, and may lie hidden in the bone substance for many months.

---

[1] As to the manner in which it is absorbed the reader is referred to the Section on bone absorption (p. 815). For microscopic appearances see Fig. 515.

The pus, on the other hand, may dry and be converted into a cheesy deposit, a state of the bone which may persist for years.

Osteitis Deformans.

1038. The above term was applied by Sir James Paget (No. 34, lx. 1877, and lxv. 1882; also, No. 567, ii. 1889, p. 181; in which see as well papers by Hutchinson, Edmunds, Lunn, Mackenzie, Humphry, Bowlby, and Robinson), to a peculiar constitutional disease in which a thickening and deformity occurs in different bones throughout the body. It is a disease chiefly of old age, and may occur in either sex, oftenest, however, in the male. In the early stages it is sometimes restricted to one bone, usually the tibia or femur, but in course of time tends to involve the bones of the skull, spine, and, it may be, nearly every bone in the body. The posture assumed by the individual is peculiar. As a rule, the spine is curved forwards and the head bent upon the chest; while the legs also present an anterior curvature. Curiously, when the swelling and deformity affect the bones of the leg the tarsal bones may remain unaltered, so that the ends of the tibia and fibula overlap them. The disease in many cases has been shown to be followed by a cancerous or sarcomatous outbreak in some part of the body. It is a very chronic affection, lasting for from ten to twenty years, and is seldom a cause of death in itself. The subjects of it sometimes become mentally alienated.

As regards the condition of the bones, it seems to be essentially a slow form of osteitis, periosteitis, and absorption, whereby new bone is deposited in parts and removed in others. Hence the characteristic deformity. Where the bone is rarefied the Haversian canals are dilated; where new bone is thrown down they are usually contracted.

According to Stilling (No. 13, cix. 1890, p. 542), the disease begins immediately underneath the periosteum or dura mater, as the case may be, and gradually spreads to the inner parts of the bone. Howship's spaces show themselves where absorption is going on indistinguishable from those of ordinary rarefying osteitis, and by their instrumentality the bone is partly destroyed. Round about where absorption is proceeding, however, a new formation of bone is also taking place, it may be within the periosteum, the medulla, or both. The two processes of osseous absorption and osseous regeneration go on side by side. The new bone is at first devoid of calcic basis, and remains so for a considerable time. Hence the bending that takes place in the long bones of the lower extremities.

Literature on Osteitis.—**Barling** (Osteitis Deformans): Illust. Med. News, ii. 1889, p. 292. **Busch**: Arch. f. klin. Chir., xxiv. 1879, p. 331. **Chitton** (Osteitis Deformans): Trans. Path. Soc. Lond., xxxix. 1888, p. 259. **Garré**: Fortschrit. d. Med., iii. 1885, p. 165. **Goodhart** (Osteitis Deformans): Trans. Path. Soc. Lond., xxxix. 1888, p. 262. **Hutchinson** (Osteitis Deformans): Illust. Med. News, ii. 1889, p. 169. **Osteitis Deformans** (Series of Papers on): Med. Press and Circ., l.

1890, p. 461. **Paget** (Osteitis Deformans): Med.-Chir. Trans., lx. 1877, p. 37; *also*, Illust. Med. News, ii. 1889, p. 181. **Parker**: Trans. Path. Soc. Lond., xxxix. 1887-88, p. 245. **Ranvier** (Osteitis, Caries, and Tubercle of Bone): Arch. d. physiol. norm. et path., i. 1868, p. 69. **Silcock** (Osteitis Deformans): Trans. Path. Soc. Lond., xxxvi. 1885, p. 383. **Stilling** (Osteitis Deformans): Arch. f. path. Anat., cxix. 1890, p. 542. **Thibierge** (Osteitis Deformans): Arch. gén. de med., 1890, i. p. 52. **Treves** (Osteitis Deformans): Trans. Path. Soc. Lond., xxxii. 1881, p. 167. **Volkmann**: Arch. f. klin. Chir., iv. 1863, p. 437.

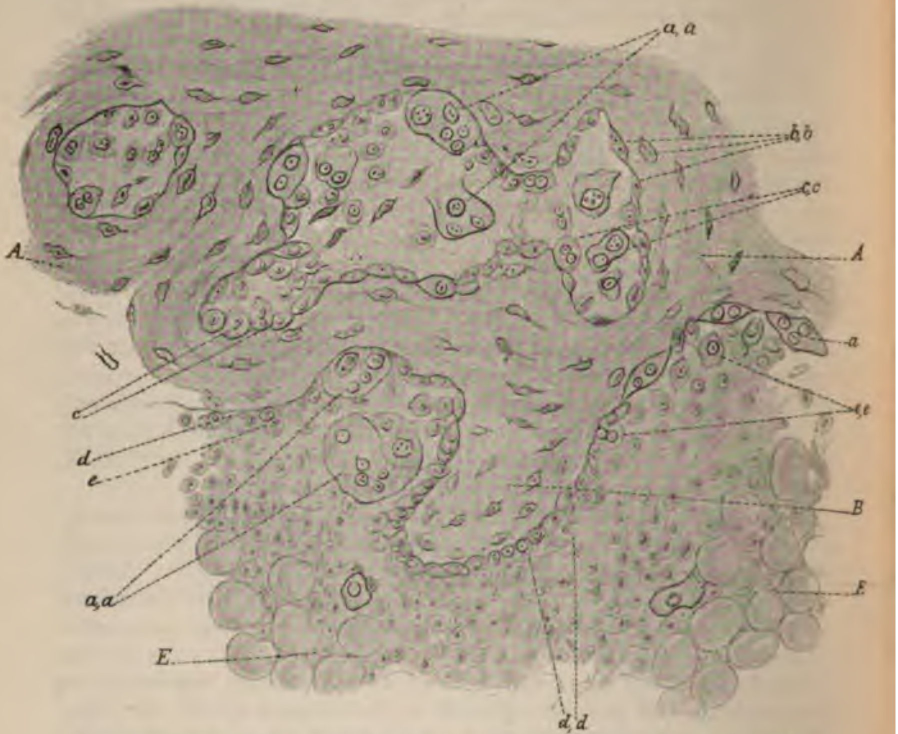


FIG. 515.—OSTEITIS, TWELVE DAYS OLD, ARTIFICIALLY INDUCED IN RABBIT'S FEMUR, SHOWING BONE ABSORPTION AND BONE FORMATION (×435 DIAMS.)

(A) Bone tissue; (B) newly formed peninsula projecting into medulla. (*a*, *a*) Giant cells or osteoclasts; (*b*, *b*) bone corpuscles undergoing transformation into osteoclasts; (*c*, *c*) small osteoclasts being transformed into osteoclasts of greater size; (*d*, *d*) osteoblasts; (*e*, *e*) osteoclasts being again transformed into osteoblasts.

OSTEOMYELITIS.

1039. The most important variety of this disease is where it is of a septic nature. No complication was more to be feared in preantiseptic times as a result of compound fracture than this septic inflammation of the medulla, and none proved a more fertile source of destruction of the bone and pyæmia.

The medulla is more or less extensively reddened from congestion of its vessels, and its interspaces are in parts bathed in pus. The result is that it assumes a peculiarly dappled appearance, some parts being yellow-coloured, others more or less red.

The parts teem with the organisms of suppuration. At one time it was supposed that the disease was caused by an organism having a special affinity for this part of the body, but the researches of Ogston, Rosenbach, Krause, Kraske, and others (see Bibliog.) have now settled that the **staphylococcus pyogenes aureus** is of itself capable of exciting the disease, and often does so, this being also the organism oftenest associated with suppuration in other parts. Garré (No. 11, 1885, p. 165) showed that the yellow coccus so abundant in the pus of osteomyelitis is identical with that occurring in carbuncles and in paranicium.

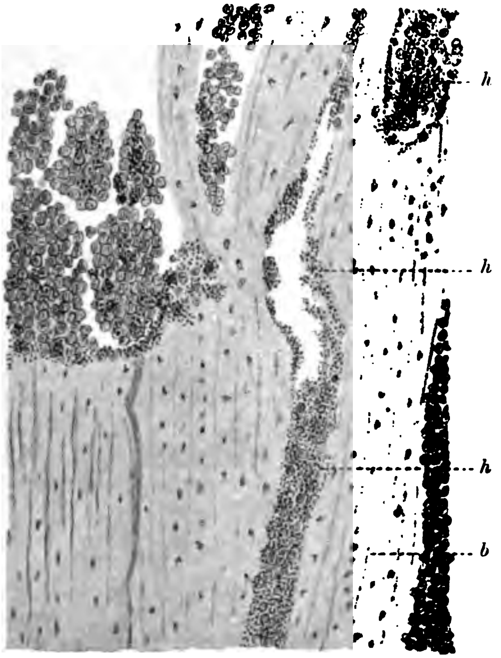


FIG. 516.—OSTEOMYELITIS ARTIFICIALLY INDUCED IN THE TIBIA OF THE RABBIT BY INJECTING A CULTURE OF STAPHYLOCOCCUS PYOGENES AUREUS INTO A VEIN OF THE EAR.

The period which intervened between the injection and the examination of the bone was five days. The drawing shows the Haversian canals distended with the organism.

(*h*, *h*, *h*) Haversian canals distended with coccus; (*b*) matrix of the bone.

In numbers of cases, however, other organisms besides the above have been found, such as **streptococcus p. albus** and **streptococcus pyogenes.** The disease is therefore the result of a mixed infection; there is the possibility that every organism which has pyogenic properties may prove to be capable of calling it forth.

Kraske (No. 92, xxxiv. 1887, p. 721) relates the case of a lad who suffered from a carbuncle-like inflammation of the lower lip, followed by an osteomyelitis of several bones of the body. The staphylococcus p. aureus was abundant both in the carbuncle and in the affected bone marrow. He regards the disease under such circumstances as a pyæmia, and the abscesses of muscles, serous membranes, etc., as co-ordinate affections. According to Tubby (No. 63, xlvii. 1890, p. 92), the medulla and the juxta-epiphysial junction are the two parts of bone which become most readily infected.

A large proportion of cases are not traumatic in their origin, and Kraske (No. 92, xxxiv. 1887, p. 701) holds that the organismal invasion under these circumstances may take place through the intestine or lung.

Literature on Osteomyelitis.—**Albert:** Allg. Wien. méd. Ztg., xxviii. 1883, p. 325 *et seq.* **Altgelt:** Beitrag zur Lehre von der Osteomyelitis, 1886. **Appelrath:** Ueb. die infectiöse osteomyelitis, 1890. **Ayala:** De portes d'entrée de l'ostéomyélite, 1886. **Francon:** De l'ostéomyélite insidieuse, 1886. **Jaboulay:** Le microbe de l'ostéomyélite aiguë, 1885. **Köstlin:** Experimentelles üb. d. acute infectiöse Osteomyelitis, 1880. **Kraske:** Arch. f. klin. Chir., xxxiv. 1886-87, p. 701. **Krause** (Micrococcus): Fortschr. d. Med., 1884, ii. p. 221. **Lannelongue and Achard:** Ann. de l'Inst. Pasteur, v. 1891, p. 209. **Mirovitch:** Des diverses formes de l'ostéomyélite, etc., 1890. **Ogston** (Micrococcus): Journ. Anat. and Physiol., xvii. 1882, p. 47. **Ribbert** (Organisms of): Deut. med. Wochnschr., x. 1884, p. 682. **Rodet:** Comptes rend. de l'Acad. des sciences, xcviii. 1884, p. 569. **Rosenbach** (Micrococcus): Centralbl. f. Chir., 1884, No. 5; *also*, Deut. Zeitschr. f. Chir., x. p. 385.

RICKETS (*Rhachitis*).

1040. **Definition.**—A disease of childhood characterised by general malnutrition and a soft pliable condition of the bones; and resulting in certain characteristic deformities.

General Features.—The rickety constitution is particularly common in this country, and is said to have been first noticed only so recently as the middle of the seventeenth century. The disease is essentially one of childhood, and may show itself from six to seven months after birth. It passes through three distinct stages, namely—

(1) The stage of incubation;
(2) The stage of deformity; and
(3) The stage of restitution.

The disease commences somewhat insidiously, the symptoms in the **first stage** being those of general malaise without any alteration pointing to the bones. There is impairment of digestion, accompanied evidently by mal-assimilation together with diminished vital power; the abdomen is swollen. The whole of the phenomena in this stage point to derangement of the processes necessary for healthy nutrition.

In the second stage the bones become characteristically deformed. The junction between epiphysis and shaft assumes a thickened and tuberose aspect, more especially in the wrist and ankle joints. The point of union between the cartilage of the rib and the bony part of the same is in a like condition, so that on passing the hand down the side of the chest a beaded feeling is communicated to it. The cartilage of the rib fits into the bone, as Virchow expresses it (No. 13, v. 1853, p. 430), like an acorn into its cupula. The union of the flat bones of the skull is interrupted, so that these bones continue ununited and the fontanelles open. The bones for long remain in a very attenuated condition and are diaphanous. The bones of the face appear to be under-developed, and the defect is rendered still more apparent from the large size of the head. Normal dentition is interrupted, or, it may be, is completely arrested, and the teeth tend to decay.

Owing to the deficiency of lime salts within them the bones are rendered pliable, and according to the pressure brought to bear upon them they yield and become characteristically deformed. Thus, from having to support the body, the **lower extremities** are bent. The convexity is usually outwards (genu varum or bow-legs), sometimes inwards (genu valgum or knock-knee). The bones of the **arm,** being less severely taxed, do not tend to yield in anything like the same degree as those of the leg, but nevertheless become bent. There may be considerable distortion of the clavicle. If the child is allowed to walk about, the **pelvis** may be driven

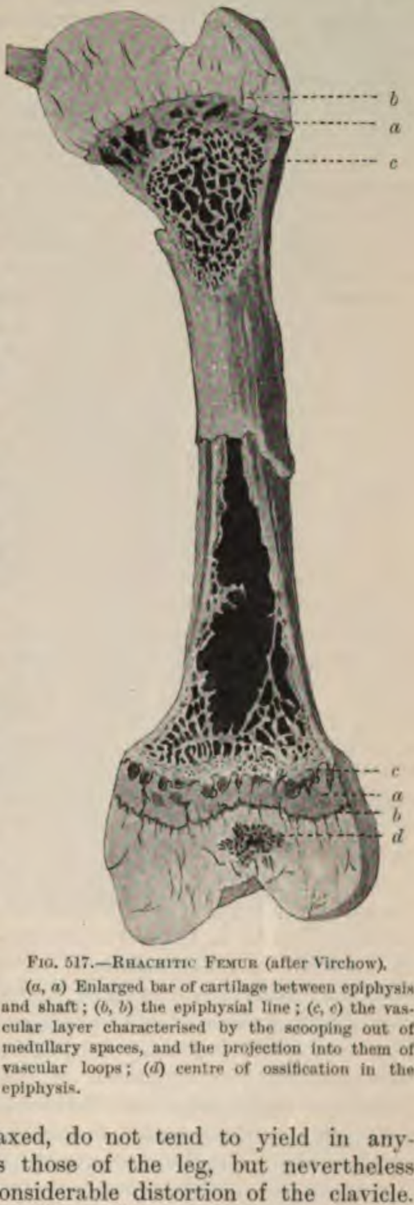


FIG. 517.—RHACHITIC FEMUR (after Virchow).

(*a*, *a*) Enlarged bar of cartilage between epiphysis and shaft; (*b*, *b*) the epiphysial line; (*c*, *c*) the vascular layer characterised by the scooping out of medullary spaces, and the projection into them of vascular loops; (*d*) centre of ossification in the epiphysis.

inwards around the acetabula, but if kept in the prone position this may in great part be avoided. The **spine** also suffers curvature, mostly an exaggeration of its natural flexures, but also in a lateral direction. The **sacrum** is driven forwards, so that this adds to the deformity of the pelvis. These deformities of the pelvis may become fixed and prove a serious complication in parturition. The pelvis also becomes deformed in *malacosteon or adult rickets*, but there is this difference between the two, namely, that in true rickets the deformity is more irregular. The **ribs**, being insufficient to resist the negative pressure of the chest during inspiration, tend to be driven in laterally, the **sternum** at the same time being protruded. The deformity is known as *pigeon-breast*, a deformity which may become permanent. The **cranial vault** is stretched and the capacity of the **skull** increased; the **brow** appears massive, but at the same time distorted. If the child rest continuously upon the occiput or parietal bone, the bone is liable to become absorbed at parts where the pressure is greatest, and apertures are formed in it. The condition was named **Craniotabes** by Elsässer. Growth is interfered with, and is not entirely compensated for later on, so that rickety individuals are generally of small stature.

When a section of a bone like the femur is made in its long axis the chief points noticeable are the large size of the bar of cartilage which intervenes between the ossific centre or centres of the epiphysis and the shaft (Fig. 517, *a*). The bar of cartilage is much more irregularly beset with absorption spaces than in a natural bone. The spaces are large and their vascularity is also greater than in health. The extreme breadth of the epiphysial line is also remarkable.

The essential pathological feature of rickety bone will be easily understood by remembering (see Sect. 1025) that bone is at first simply a laminated fibrous tissue, and that ossification is completed by the calcic salts being precipitated in the interstices of this fibrous matrix.

In rickets the osteoblasts are superabundant, and they arrange themselves around the margins of the absorption spaces in the cartilage just as in natural ossification. They go so far in fulfilling their developmental intention as to throw out the fibrous matrix of the bone, which even assumes a homogeneous appearance, probably from being infiltrated with collagen. But here the process ceases. The final stroke necessary to convert the fibrous matrix into true bone, namely, the deposition of calcareous salts, is wanting. The osteoblasts either have lost for the time being the power of secreting these salts, or the materials necessary to form them fail to be brought to the part. The bone, consequently, does not seem to elongate. The crude fibrous tissue, which is its sole representative, accumulates at the epiphysial line, and along with the unduly great vascularity and the wide absorption spaces in the cartilage, occasions the tuberose swellings so characteristic of the disease. The bone which has already been laid down does not vanish, but remains in its originally cancellous state; while round the borders of its trabeculæ there is a deposit of fibrous tissue, the sole representative of the bone which has been newly formed. The former with picro-carmine stains yellow, the latter pink. All further ossification is arrested. Rarely, if ever, does the cartilage appear to have undergone the calcification preliminary to ossification. The periosteal bone is likewise represented by fibrous

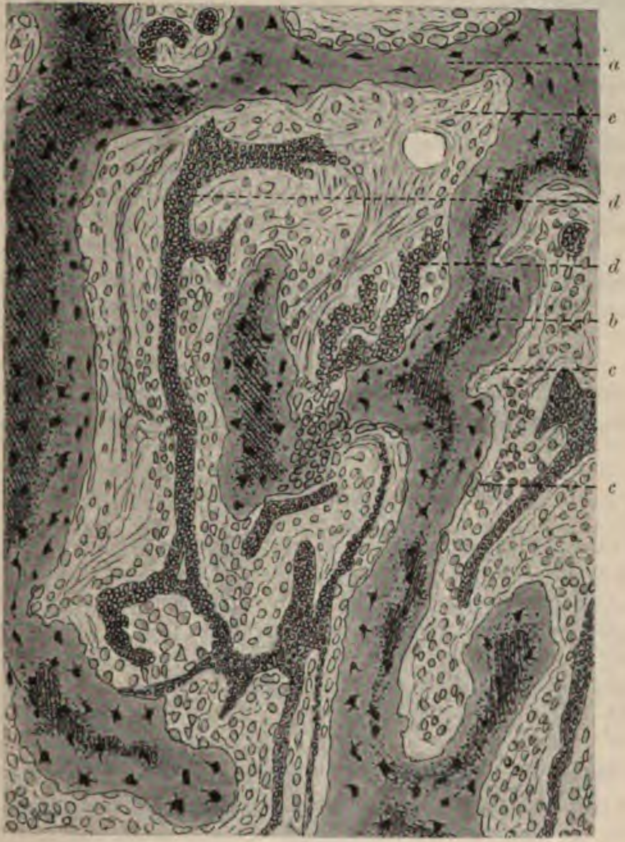


FIG. 518.—SECTION OF RICKETY RIB OF CHILD CLOSE TO THE CARTILAGE (×300 DIAMS.)

(*a*) Trabecula of uncalcified bone; (*b*) central part of trabecula with slight deposit of calcareous salts, deposited probably before the attack of rickets supervened; (*c*, *c*) osteoblasts lying in contact with the (fibrous) bone; (*d*, *d*) blood-vessels in trabecular spaces; (*e*) loose fibro-cellular tissue filling the space (Picro-carmine and Farrants' Sol.)

tissue. It is laid down in successive laminæ without usually a vestige of calcification in its midst.

The third stage is that of restitution, and in this, ossification sets in with unusually great vigour. The deformities at the ends of the long bones disappear, and the curvatures which may have taken place in them often right themselves in a wonderful manner, although, in most instances, the bones of the lower extremities to a certain extent remain permanently bent. During the height of the disease periosteal ossification, as can be well supposed, is also arrested, but in this stage it regains vigour, alike with that which is manifesting itself within cartilage. Massive relays of periosteal bone are thrown down beneath the periosteum, and seemingly, as a substitution for the loss of mechanical advantage caused by the curvatures, this periosteal deposit is greatest on the concave aspects of the bones. The amount of the deposit seems almost proportional to the extent of the bending. The bones of the head, pelvis, and thorax do not show anything like the same restorative power possessed by the long bones.

As may be supposed, rickety bones become unusually dense in later life, and it happens frequently that if the permanent deformity be great, the muscular system is correspondingly over-developed.

Chemical Analysis of the Bones in Rickets.

If examined when the disease is at its worst, the bones, from the deficiency in earthy salts, will be found to be specifically light. The water and organic matter within them is increased. The fat also seems to be considerably over the average, but is not in so great quantity as in mollitics ossium. Halliburton says (No. 568, p. 511) that occasionally they do not yield normal gelatine.

The following table taken from various analyses (quoted from Charles' *Physiol. and Path. Chem.* p. 305) gives the relative composition of the bones in rickets and in the normal bone of a child:—

In 200 Parts.	Healthy Bones of Child. Aged 2 months (v. Bibra).		Rhachitic Bones.		
	Tibia.	Ulna.	Femur. (Marchand).	Tibia. (Lehmann).	Humerus. (Ragsky).
Inorganic matters	65·32	64·07	20·60	33·64	18·88
Organic matters	34·68	35·93	79·40	66·36	81·12
Calcium phosphate	57·54	56·35	14·78	26·94	15·60
Magnesium phosphate	1·03	1·00	0·80	0·81	
Calcium carbonate	6·02	6·07	3·00	4·88	2·66
Soluble salts	0·73	1·65	1·02	1·08	0·62
Calcium fluoride and loss	—	—	1·00	0·99	81·12
Collagen or ossein	33·86	34·92	72·20	60·14	
Fats	0·82	1·01	7·20	6·22	

Essential Pathology of Rickets.

There are several possibilities. Thus it might be (1) that there is something inherently wrong in the secretive activity of the osteoblasts; (2) that there is a deficiency in the earthy salts, and more particularly the phosphates contained in the food; or (3) that the essential salts are not absorbed from the digestive tract. All these theories have had their champions, but as yet it may be said that no very conclusive arguments have been adduced for the one or the other. Of them all, the first, that which presupposes an inherent metabolic defect in the osteoblasts, seems the most feasible. The osteoblast is so closely related to the ordinary fibroblast that it is quite conceivable it might lose its true bone-forming properties, and revert to what has in all probability been its primitive type.

Of course if bone salts are totally withheld from the food the bones will suffer. Thus Lehmann (No. 569, 1878, p. 495, reported in No. 570, 1878, p. 987) found that a young pig fed exclusively on potatoes developed softening of the bones after an interval of 126 days. They remained, as might be expected, soft, translucent, and pliable. It is to be questioned very much, however, whether a habit of body so induced is comparable with that of rickets. In rickets there seems to be some deeper-seated defect in the bone-secreting mechanism than can be accounted for by mere abstention from the necessary salts. This is borne out by the almost complete want of success following the administration of bone salts medicinally even in excess.

The connection of the disease with **syphilis** has often been mooted but never conclusively proven. The conditions which engender and perpetuate the disease appear to be those which may be included under the term *bad hygienic surroundings*. The disease is most rife among the denizens of the slums of large cities; it is almost unknown where the conditions of life approach ideal perfection. The rickety constitution seems to be distinctly hereditary.

It should be mentioned, as tending to disprove the syphilitic theory of the disease, that rickets is common in the **lower animals** such as the calf, pig, and especially the dog. It commences usually within a few weeks after birth.

FŒTAL RICKETS (see *Cretinism*).

Literature on Rickets.—**Kirchberg and Marchand** (Fœtal, with Numerous References): Beiträge z. path. Anat. u. z. allg. Path. (Ziegler), v. 1889. **Neumann**: Ueb. fœtale Rachitis, 1881. **Pommer**: Osteomalachie u. Rachitis, 1885. **Roloff** (in Animals): Arch. f. path. Anat., xxxvii. 1866, p. 433. **Schütz** (in Dog): Arch. f. path. Anat., xlvi. 1869, p. 350. **Smith**: Internat. Encycl. Surg. (Ashurst), i. 1882, p. 251. **Stiebel**: Virchow's Handb. d. spec. Path. u. Therap., i. 1854, p. 527. **Virchow**: Arch. f. path. Anat., v. 1853, p. 409.

CHAPTER LXXXIX

DISEASES OF BONE AND JOINTS—(*Continued*)

MOLLITIES OSSIUM, OSTEOMALACHIA OR MALACOSTEON.

1041. THIS disease is sometimes called adult rickets. With the exception, however, of the bone salts being deficient both in malacosteon and rickets, and thus allowing of the bones bending, there is nothing to lead one to suppose that they have much in common. It appears to be peculiar to women who are pregnant or who have already borne a child. It is continually mistaken for fragilitas ossium, a disease in which the bone becomes unusually fragile and breaks. The published accounts of the puerperal disease do not indicate that the bones are particularly fragile, but rather that they bend like a rickety bone and become distorted. So great is the distortion that sometimes the bones of the inferior extremity may be capable of being twined round the neck of the individual. Fragilitas ossium, on the contrary, is not necessarily, nor is it generally, accompanied by distortion. The mollities of child-bearing women seems to possess characters of its own which do not exactly run parallel with any other form of bone affection.

It is essentially a disease of adult life, coming on usually from twenty-five to thirty-five years of age, and has a predilection for the flat bones such as those of the pelvis, and for those of the trunk. In certain instances nearly every bone in the body may be the subject of it. Up till the time of onset the bones generally may have been healthy enough.

The disease commences in the pelvic bones. They become softened gradually, but to such an extent that they yield to strain and assume characteristic deformities. Perhaps the most disastrous is that of the pelvis. The acetabulum is driven in by the head of the femur, and the lumbar vertebræ are pushed forwards and downwards. In this position the bones become permanently fixed, the deformity interfering seriously with parturition. There is not the same tendency to this deformity in rickets, because very often the child is not walking at the time of the attack, and hence the acetabulum is not driven inwards.

The disease is usually aggravated by successive pregnancies. The future of the individual is not hopeless; the disease may be arrested. A large proportion, however, of the subjects of the disease die from the complications of labour caused by the deformities, many from interference with respiration, caused by deformity of the chest and spine, complicated with general malnutrition.

There is difficulty in finding a reliable account of the general condition of the bone in this puerperal disease. The bone is usually described as being of a peculiar wax-like consistence, so that in severe cases it may be bent like one which has been decalcified. The medulla is also described as being red from congestion, so much so that the disease has been regarded (Litzmann) as of inflammatory origin. The presence of an excess of oil in the bone seems to be admitted on all hands.

As regards the histological appearances, data are equally unsatisfactory. The general impression is that the *halisterisis* or absorption of lime salts commences at the edge of the trabeculæ and proceeds inwards. The author is also unaware of a reliable comparative analysis of the bones in this disease.

There is nothing known of its intimate pathology. It has been asserted, but the theory seems very crude, that the fœtus absorbs the bone salts necessary for the maintenance of the maternal bone.

FRAGILITAS OSSIUM.

1042. The most prominent feature of this disease is the biscuit-like brittleness of the bones; so extreme is this that they fracture on the slightest strain. It is common among old people, in the inmates of asylums for the insane, and very often in those who have suffered and it may be died from cancerous or sarcomatous disease. Of all the bones in the body the ribs are those which suffer most, but the long bones of the limbs and the vertebræ are also often contemporaneously affected. The humerus may snap across on being bent between the two hands.

The bone seems to be particularly porous internally, and the dense casing of periosteal bone is attenuated. The brittleness does not appear to reside so much in a want of bone salts as in an extreme rarefaction of the bone. Hence the bone becomes brittle without being much bent.

Histologically, Langendorff and Mommsen (No. 13, lxix. 1877, p. 474) make out that there is dilatation of the Haversian canals, which in part are transformed into medullary spaces. The cement lines (v. Ebner) which intervene and map out the borders of the Haversian systems have almost vanished. The borders of the trabeculæ of bone stain red with carmine, probably owing to their being deprived of their calcic salts. It is usually said that during the progress of the disease

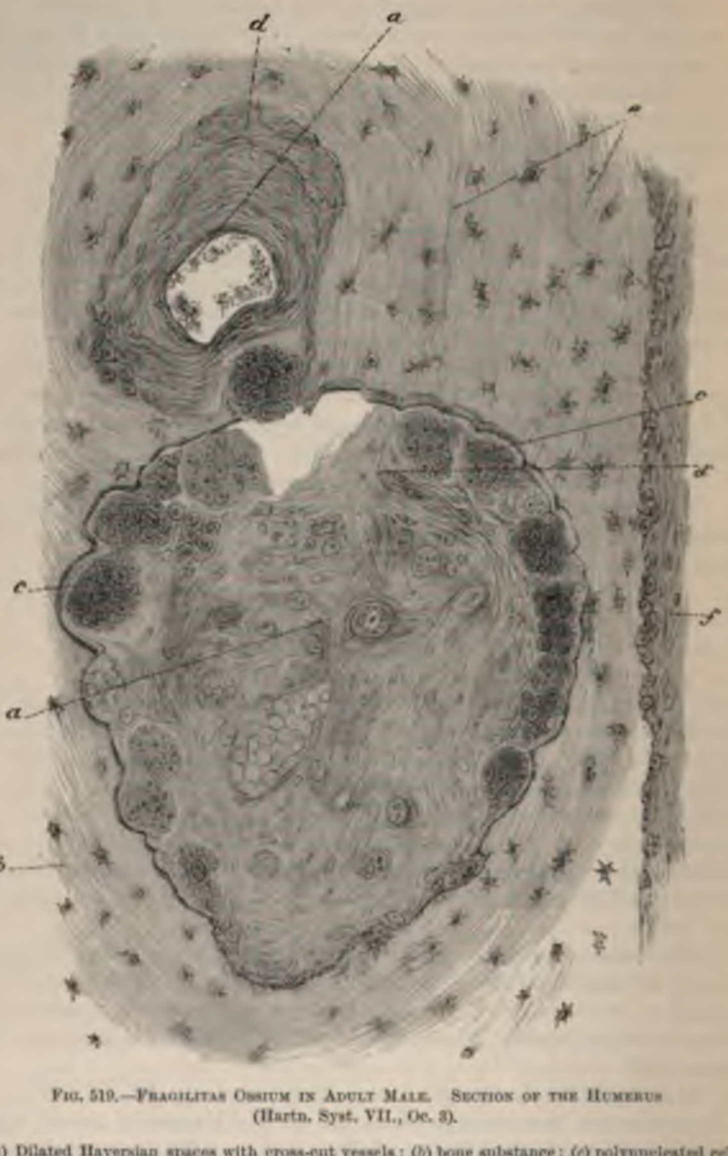


FIG. 519.—FRAGILITAS OSSIUM IN ADULT MALE. SECTION OF THE HUMERUS (Hartn. Syst. VII., Oc. 3).

(*a*, *a*) Dilated Haversian spaces with cross-cut vessels; (*b*) bone substance; (*c*) polynucleated cells and Howship spaces; (*d*) spindle-shaped elements; (*e*) indistinct cement lines.

the bone marrow is red and hyperæmic, full of cells and poor in fat;

but that when stationary it becomes yellow, loaded with fat, and, lastly, transformed into a hyaline gelatinous tissue. When red it comes to resemble fœtal marrow (Virchow). In the case examined by Langendorff and Mommsen, that of a man with multiple fractures, the yellow marrow where it prevailed was not abnormal, while the red

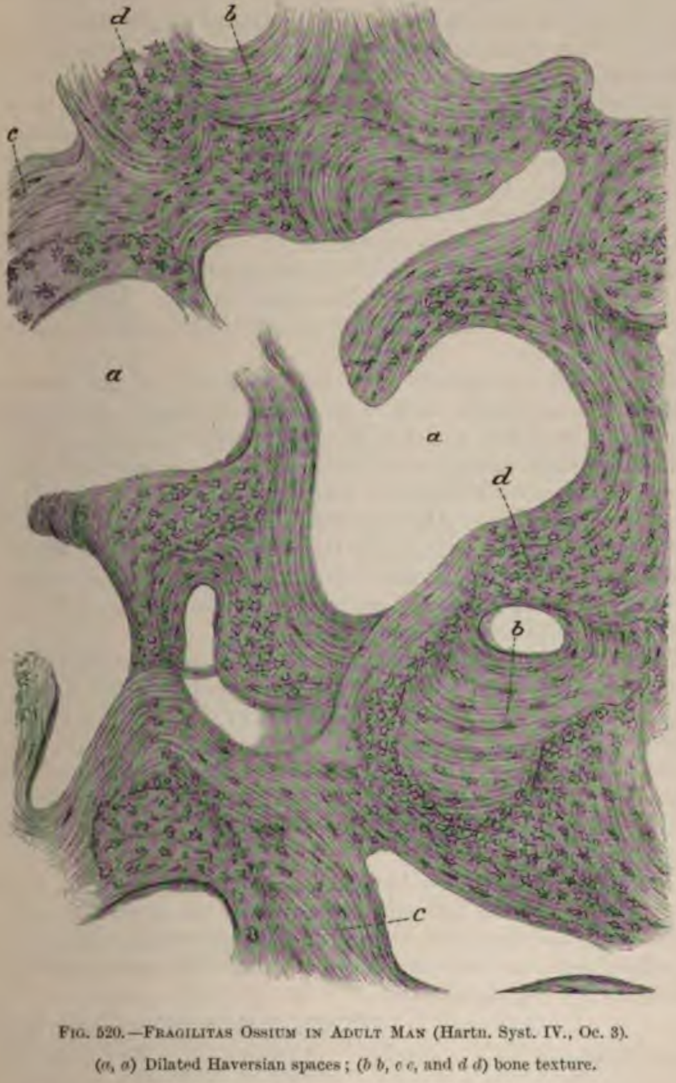


FIG. 520.—FRAGILITAS OSSIUM IN ADULT MAN (Hartn. Syst. IV., Oc. 3).

(*a*, *a*) Dilated Haversian spaces; (*b b*, *c c*, and *d d*) bone texture.

marrow was infiltrated with numerous round cells. Giant-cells were contained in the dilated Haversian canals (Fig. 519). Cyst-like cavities were also found, the largest of which were lined by a membrane and contained a clear alkaline fluid. The small cysts were filled with a rust-brown coloured liquid containing granular matter and fat drops. He thinks that these cysts were due to hæmorrhage. In some cases of fragilitas ossium or osteomalachia, as he calls it, there was an absence of giant-cells. Parts of the bone showed the trabeculæ to be purely fibrous (Fig. 520). Weber (No. 13, xxxviii. 1867, p. 3) stated that after the salts are removed a fibro-cartilaginous texture remains which may be in a state of proliferation and occasion a species of enchondromatous degeneration of the bone.

The disease would thus appear to be one in which the bone salts are partially removed, but in which subsequently a rarefaction of the bone ensues by distension of its Haversian canals. The spaces thus formed in course of time come to be filled with medulla containing much fat.

It might be expected that during the height of the disease **the urine** would be loaded with bone salts. Litzmann stated that, in several cases, he found it rich in phosphate and carbonate of lime. A white chalky sediment separated from it, which in one case dissolved with effervescence on addition of a mineral acid. Confirmatory statements have been made by Weber and Billroth. Other observers, however, have not been able to verify these assertions. Thus Moers and Muck could never find increased excretion of lime in three cases they had under observation. Langendorff and Mommsen, in their case, never found the amount of lime altered.

Theory of its Pathology.—It has been asserted that the cause of the removal of the bone salts is the presence of an acid in the part. In two cases examined by Weber (No. 13, xxxviii. 1867, p. 10) it was asserted that the medulla of the bone gave an acid reaction from the presence of lactic acid. It was in considerable quantity and readily combined with zinc oxide. It has also been asserted to be present in the urine, but this may have been accidental, as lactic acid is a common constituent of urine.

Chemical Analysis.—Langendorff and Mommsen (No. 13, lxix. 1877, p. 471) give the following relative analysis of normal bone and of that from the case just referred to. The normal bones used for comparison were as nearly as possible under the same conditions as those affected with the disease:—

	Norm. Bone.	Osteom. Bone.
Total weight of bone examined	13·8663	11·7143 Gr.

Out of 100 parts they obtained of

	Norm.	Malac.
Fat	24·31	60·38
Bone deprived of its fat . .	75·69	39·62

		Norm.	Malac.
Out of 100 parts of Bone deprived of its fat	Ash	54·24	37·8
	Organ. Sub.	45·76	62·2

They estimated the phosphoric acid and lime in the ash by weighing, and found—

	Norm. Bones.	
Ash	1·7484	In 100 parts
CaO	0·9276	53·05
PO_5	0·7680	43·93
Residue not analysed	0·0528	3·02
	Osteom. Bones.	
Ash	0·9422	In 100 parts
CaO	0·4190	44·48
PO_5	0·3275	34·76
Residue	0·1957	20·76

The above point in particular to two facts, namely, that the amount of **fat** contained in the bones of osteomalachia is vastly increased, while that of the **lime** is sensibly diminished.

Literature on Osteomalachia and Fragilitas Ossium.—**Dowse**: Trans. Path. Soc. Lond., xxiii. 1872, p. 186. **Duncan (J. M.)** [Rickety and Malacosteon Pelvis]: Edin. Med. Journ., i. 1856, p. 917. **Gibb** (Chemical Constituents in): Trans. Path. Soc. Lond., xiii. 1862, p. 210. **Heitzmann** (Feeding with Lactic Acid): Maly's Jahresbericht, iii. 1874, p. 229. **Langendorff and Mommsen**: Arch. f. path. Anat., lxix. 1877, p. 452. **Lindsay** (in Insane): Edin. Med. Journ., xvi. 1870, p. 414. **Litzmann**: Die Formen des Beckens, 1861 (*Eng. Transl.* by M. Duncan, Edin. Med. Journ., vii. 1862, p. 453). **Moers and Muck**: Deut. Arch. f. klin. Med., v. 1869, p. 485. **Pommer**: Untersuch. üb. Osteomalachie u. Rachitis, 1885. **Ribbert** (Senile): Arch. f. path. Anat., lxxx. 1880, p. 436. **Roloff**: Arch. f. path. Anat., xxxvii. 1866, p. 433; *Ibid.*, xlvi. 1869, p. 305. **Schmidt** (Lactic Acid in Bones): Ann. d. chemie u. Phar., lxi. 1847, p. 142. **Schmuziger** (Urine in Puerperal): Centralbl. f. d. med. Wissensch., xiii. 1875, p. 946. **Senator**: Cycl. Pract. Med. (v. Ziemssen), *Eng. Transl.*, xvi. 1877, p. 209. **Shattack**: Trans. Path. Soc. Lond., xxxviii. 1887, p. 270. **Weber** (Chemistry of): Arch. f. path. Anat., xxxviii. 1867, p. 1.

OSTEO-SCLEROSIS.

1043. A sclerous condition of bone has already been referred to as resulting from osteitis (p. 826). It happens frequently that a bone which has become unusually porous from rarefying osteitis increases correspondingly in density as the inflammation subsides.

There is a peculiar disease, however, and one which affects chiefly the bones of the skull, in which a sclerotic state of the bone ensues without any distinct evidence of inflammation. It has been termed **hyperostosis cranii** or **cranio-sclerosis.** It appears to commence in the bones of the vault and subsequently spreads to those of the face.

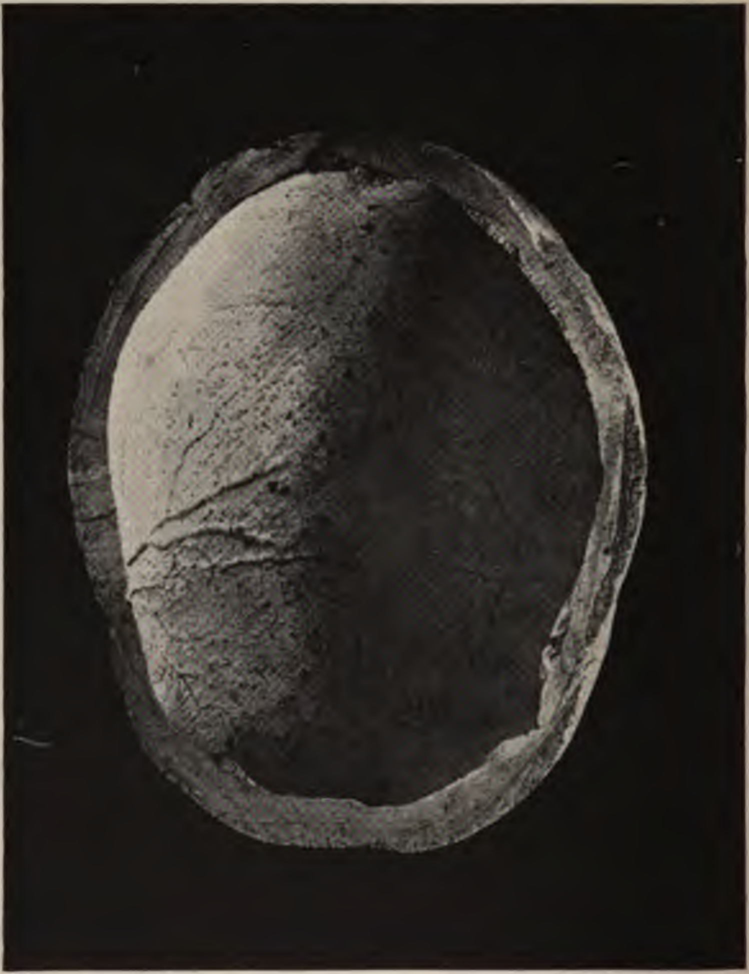


FIG. 521.—OSTEO-SCLEROSIS. CALVARIA OF A MAN WHO DIED WITH ALL THE BONES OF THE SKULL IN AN IVORY-LIKE CONDITION.

The diploë was entirely converted into sclerous bone.

The bone is so thickened that it may measure from 1 to 2 inches on section. The diploë has vanished and its place is taken by bone of unusually great density. The skull is much increased in weight and has the ring of a mass of ivory. The cranial cavity is encroached upon by the thickened bone and the orbits similarly become progressively narrowed in capacity. The nerves and vessels of the skull suffer compression, so that sometimes symptoms in accordance with the parts affected are forthcoming. In other cases, however, the disease proceeds almost without a single symptom.

OSTEO-POROSIS.

1044. This also, as already detailed (p. 826), may result locally from inflammation of a bone, and is very often seen in the heads of bones as a result of tuberculosis and its accompanying vascular distension.

There is a general disease, however, which is found more often in the lower animals than in Man, where the bones appear to become rarefied and spongy without any very apparent exciting cause. The horse is most liable to the disease, and the bones of the head and face are often the seat of it.

The affected bones assume a swollen appearance; their angles are rounded off; and the head consequently increases in dimensions. So far as the author is aware, there is no very reliable account existing of the minute changes in the bone in this disease.

SYPHILITIC DISEASE OF BONE.

1045. As in other parts, syphilis of bone, which is a common disease either in its congenital or acquired form, manifests itself by a more or less chronic inflammation. This inflammation is followed by excessive deposit of new tissue, by the formation of gummata, and by a tendency to ulceration.

In the majority of cases the disease shows itself first in the periosteum, and may remain restricted to it. Very often, however, the bone becomes invaded and destroyed. The periosteitis in such cases is characterised by the inflammatory tissue tending to accumulate in foci, so that nodular thickenings come to lie in the substance of the membrane or between it and the surface of the bone. These are known as **syphilitic nodes.** Their centres frequently caseate and become converted into yellow gummata.

Syphilitic osteitis affects chiefly the bones of the calvaria, the nasal bones, clavicles, and occasionally the long bones of the extremities such as the tibia. It commences as a periosteitis which gradually implicates the bone substance. The bone becomes very dense and sclerous; the diploë disappears, and the medullary canal of the long bones is encroached upon by the sclerous surroundings. The thickening which occurs in the bone is not universal, but is distributed in patches on a flat bone or forms a fusiform thickening throughout the entire circumference of a long bone. The hard bone tissue now begins to ulcerate from the surface inwards. At first there is a mere roughness of the surface from minute erosions upon it like Howship's lacunæ, only not so sharply punched out. The destruction proceeds deeply into the dense basis, and finally may perforate in the case of the skull or open into the medullary cavity of a long bone. The destruction, to begin with, is gradual, but after a time a sequestrum may separate owing to the bone having been deprived of its periosteum. The pus and débris resulting from the disintegration of the bone tissue tend to accumulate under the periosteum and to force it

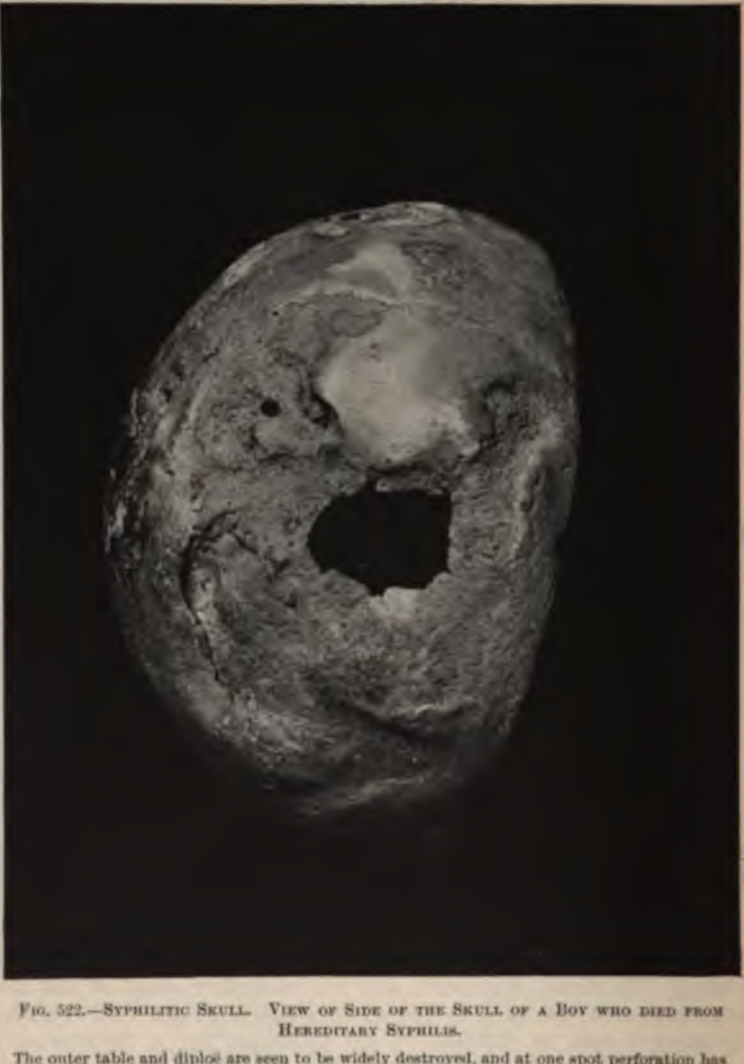


FIG. 522.—SYPHILITIC SKULL. VIEW OF SIDE OF THE SKULL OF A BOY WHO DIED FROM HEREDITARY SYPHILIS.

The outer table and diploë are seen to be widely destroyed, and at one spot perforation has occurred.

upwards into a sac. The bone may thus be laid bare for a distance of an inch to an inch and a half round the ulcerated part, and this exposed bone may die and be thrown out in mass. The ulceration may have proceeded for long before the skin becomes perforated, but in course of time the products of destruction find their way to the surface and perforate. They thus form a **syphilitic sinus.** The opening in the skin is not usually so large as the ulcerated surface of the bone.

When the medullary cavity is perforated the discharge from the ulcerated part may accumulate within it, and become inspissated so as to present the appearance of a carious mass. Particles of bone are included among the débris, and the term **syphilitic caries** is sometimes applied to the condition.

The amount of pus thrown off from a syphilitic bone is sometimes very small. It is said that the calvaria may become perforated without almost a drop of pus presenting itself.

Where the skull is perforated the adjacent dura mater lies exposed in the depth of the wound, and death may result from meningitis (see p. 568). This accident is, however, often warded off by the dura becoming very closely adherent to the sides of the vacuity.

The bone which is lost by ulceration never seems to be reformed. Cicatrisation of the surrounding soft parts takes place, and they become puckered down to the floor of the ulcer. There remains, however, a distinct dimple-like or cup-shaped depression in the bone. When this occurs the destructive ulceration ceases, and often no further trouble is experienced. Even where the skull has been extensively eaten into, the individual may live into old age, but always with the mark of his early infirmity indelibly printed upon the part.

Syphilitic disease of the joints is not so common an ailment as that of the periosteum and bone. When the disease has been acquired it may take the form, either in the secondary or tertiary stage, of an acute or subacute serous effusion. Sometimes a true gummatous inflammation of the capsule shows itself in the tertiary stage; or the joint may become inflamed secondarily to a syphilitic inflammation of the bone or periosteum. In hereditary syphilis the disease much more often assumes the epiphysial type seen in children (p. 846). In this the joint may become secondarily implicated (Schüller, No. 92, xxviii. 1882, p. 473).

In Children.—Syphilis is a rare bone disease in the newly-born. Out of a series of forty instances of children undoubtedly syphilitic at birth annotated by Wegner (No. 13, l. 1870, p. 306) at the Charité of Berlin, there were only two in which disease of the bones of the skull was noticed. Disease of the long bones was commoner. A common syphilitic affection of the periosteum in children is that of gumma-like nodules about the size of a millet-seed or lentil. They are hard and yellow, and either lie embedded in the substance of the membrane or project from it. They are often situated in the frontal or occipital region.

When syphilis has shown itself indubitably in the infant, the bones, according to the above authority (p. 308), may in course of time become affected as follows:—

In the first stage the chief deformity is in the border line between the epiphysis and diaphysis. This is broader than in a healthy bone, and the increased breadth is due chiefly to the unusually great dimensions of the area of cartilaginous calcification.

In the second stage not only is this area of calcified cartilage even more extensive, but it has a peculiarly irregular margin on the epiphysial side, owing to there being irregular islands or peninsulas of calcification extending into the cartilaginous substance. Examined microscopically, the rows of cartilage cells are seen to be unusually prolific, while the intervening matrix is meagrely developed; blood-vessels are exuberant within the calcified cartilage, and there is evident delay in the conversion of this into true bone tissue.

In the third stage the affected joints as well as the border zone between the epiphysis and bone assume a rickety appearance. The perichondrium and periosteum at the epiphysial margins become thickened. Microscopically, the appearances are those noticed in the second stage in a state of exaggeration, and in addition, within the zone of calcified cartilage, there are portions of caseous (gummatous ?) tissue.

Literature on Syphilitic Disease of Bone and Joints.—**Bowlby** (Syphilitic): St. Barth. Hosp. Rep., xxvi. 1890, p. 83. **Haab:** Arch. f. path. Anat., lxv. 1875, p. 366. **Hamilton (J.):** Lectures on Syphilitic Osteitis and Periosteitis, 1874. **Landerer** (Syphilitic): Arch. f. klin. Chir., xxx. 1884, p. 217. **Müller:** Arch. f. path. Anat., xcii. 1883, p. 532. **Parrot (J.):** Arch. d. physiol. norm. et path., iv. 1871-72, p. 319 *et seq.*; *Ibid.*, iii. 1876, p. 133; *also* (in Newly Born), Bull. Soc. Anat. de Paris, xlviii. 1873, p. 92; *Ibid.*, l. p. 470. **Rasch:** Arch. f. Dermatol. u. Syph., xxiii. 1891, p. 91. **Schüller** (Syphilitic): Arch. f. klin. Chir., xxviii. 1882, p. 473. **Stewart:** Illust. Med. News, iii. 1889, p. 289. **Stilling:** Arch. f. path. Anat., lxxxviii. 1882, p. 509. **Taylor:** Syph. Lesions of the Osseous System in Infants and Young Children, 1875. **Veraguth:** Arch. f. path. Anat., lxxxiv. 1881, p. 325. **Virchow** (Syphilitic): Berl. klin. Wochnschr., xxi. 1884, p. 534. **Wegner:** Arch. f. path. Anat., l. 1870, p. 305.

TUBERCLE OF BONE AND JOINTS.

The Structure and Connections of Synovial Membranes and of the Capsules of Joints.

1046. The synovial membranes, it will be remembered, are inseparably attached to the capsule of the joint externally, while internally they are smooth and free. They are composed of white fibrous tissue bundles, with a certain admixture of yellow elastic fibres. The attachment to the capsule of the joint is effected through a layer of somewhat loose areolar tissue, with occasional fat and cartilage cells in it. This layer contains many blood-vessels, whose capillaries penetrate to the substance proper of the membrane. The joint surface of the membrane is covered by a layer of rounded or polygonal endothelial cells.

On their inner surfaces there are certain folds and projections of considerable pathological importance. They are known as **plicæ synoviales.** Some of them are mere vascular ridges of fat, and are known as *plicæ adiposæ*, s. *glandulæ Haversianæ.* Others are more exclusively vascular—*Plicæ vasculosæ*—and are present in all joints. They are located at the borders of the cartilages. They are often branched, and are composed of an artery and vein bound together by white fibrous tissue and a few cartilage cells. A nerve also runs into them. The main vessels split up into a fine capillary plexus. Projecting from their free extremities are smaller villus-like bodies—the **synovial villi.** They repeat very much the structure of the plicæ vasculosæ, but from them often a delicate thread-like connective tissue process is pushed into the joint, whose substance at the free extremity is composed of mucoid tissue.

Beneath the endothelium of the membrane lies an abundant plexus of lymph-spaces.

The synovial membrane ceases at the margin of the articular cartilages. The texture of the one passes insensibly into that of the other. The cartilages are devoid of endothelial investment. On the surface of certain articular cartilages, however, according to Weichselbaum (No. 12, lxxv. Ab. III. H. 1-5, 1877, p. 204), more particularly those of the heads of the humerus and femur, there is to be seen a delicate layer of tissue which looks at first as if it were simply the dried surface of the cartilage. He regards it as the remnant of the synovial membrane which at an earlier period covered the cartilaginous end of the bone.

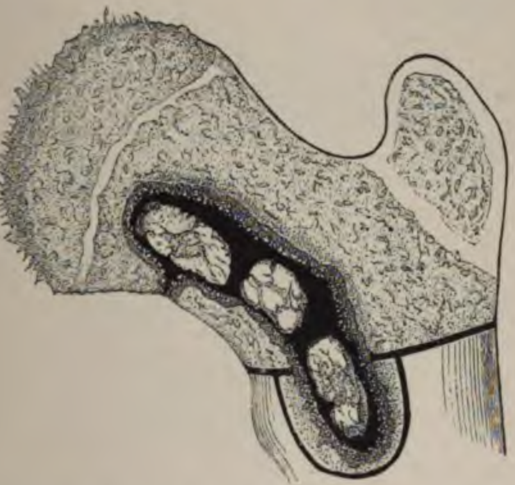


FIG. 523.—TUBERCLE OF NECK OF FEMUR IN AN EIGHT-YEARS-OLD BOY.

The dark lines indicate the direction in which resection was practised.

It will further be borne in mind that the capsule of the joint is mainly a fibrous texture, but that it contains cartilage cells; and that it is continuous with the outer layer of periosteum.

History of the Subject of Tubercular Conditions of Bone and Joints.

Since the discovery of the tubercle bacillus, the pathology of many obscure diseases of bone, and more especially those which were formerly known as strumous bone and joint affections, has been completely revolutionised. These so-called strumous affections of bone remain local for months or years without setting up an auto-infection of other organs, hence they were often regarded as something different

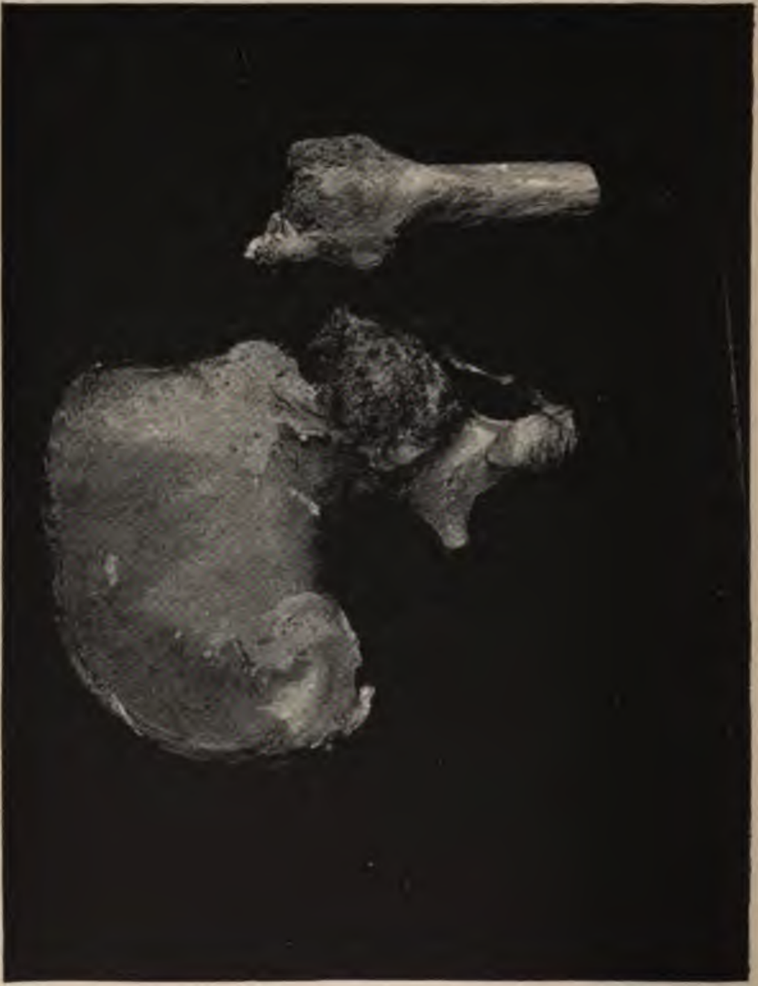


FIG. 524.—ILIUM AND UPPER END OF FEMUR FROM A CASE OF OLD-STANDING TUBERCULAR DISEASE OF THE HIP.

from ordinary widespread tuberculosis. We now know that this localisation in a particular focus in the body is one of the characteristics of the tubercle bacillus, and that these strumous diseases of bone and joint are in reality localised tubercular affections.

The tubercle bacillus is not always so easy to find within such affected parts, but can be demonstrated on sufficiently diligent search being made, particularly in the commencement of the disease. Later on tubercle bacilli are found only here and there, so much so that Cheyne (No. 6, 1891, i. p. 743) supposes them to undergo some alteration whereby they stain less readily than in other situations. Injection of a pure culture of tubercle bacilli into the joint directly or into the nutrient artery of the bone excites in the bone and joint a fungating disease analogous to that which is now held to be indicative of a tuberculosis.

König (No. 43, viii. 1871, p. 229) and Volkmann (No. 114, No. clxix., Chir. No. li.) were the first to assert the tubercular nature of these diseases of joints, and this mainly from the purely histological characters of the affected parts. Their observations were made long before the tubercle bacillus was discovered. What they asserted has been amply confirmed since the true pathology of tuberculosis became known. König established that many instances of cheesy suppuration of joints were to be explained by the presence of tubercular deposit in the synovial membrane; and that bodies having all the histological characteristics of tubercle were to be found in the fungating granulations of joint-sinuses.

The term **caries** is one which has long been in use to designate a peculiar broken-down and disintegrated condition of a bone. The bone becomes softened and rarefied, while its interstices are filled probably with half-purulent discharge containing much granular and oily débris. Before we were possessed of a definite knowledge of either the histological or parasitical features of tubercle, Volkmann (No. 92, iv. 1863, p. 454) described it as *an ulcerative destruction of bone tissue accompanied by the discharge of sanies and pus.* The red fungating softening which accompanies such a condition of bone he regarded as something different from the caries itself. It had, according to his notions at that time, more the character of an osteitis.

These views, however, were renounced by him at a later period, when he recognised that caries, so called, and its surrounding fungating granulation tissue were not in themselves evidence of separate diseases, but were simply part and parcel of one disease—and that tuberculosis.

The terms *caries, fungous joints, strumous affections of bone, white swelling,* and so on, however applicable they may have been in the past, must now be regarded as remnants of an antiquated pathological nomenclature. The diseases to which they are applied are all manifestations of tuberculosis.

Morbid Appearances.

The disease usually shows itself within **short cancellous bones** such as those of the wrist, ankle, or vertebral column. Their cancellous interior seems to favour its development. The **ends of the long bones** abutting upon the knee, elbow, and hip joints are also selected localities. The middle of the shaft is seldom a primary seat of tuberculosis. The flat bones enjoy a peculiar immunity.

If the tubercular part of the bone enters into the formation of a joint, the *synovial membrane*, the *capsule*, and it may be the *surrounding fibrous tissues* in course of time will be found to be implicated. The synovialis and the joint capsule are usually profoundly diseased. The inner surface of the former is either covered with a thick layer jelly-like **fungating granulations,** or bunches of these hang fr the vascular fringes. Beneath the surface the parts assume a gelatin appearance (gelatinous degeneration), probably due to their be infiltrated with mucin, or they become unusually fibrous. T

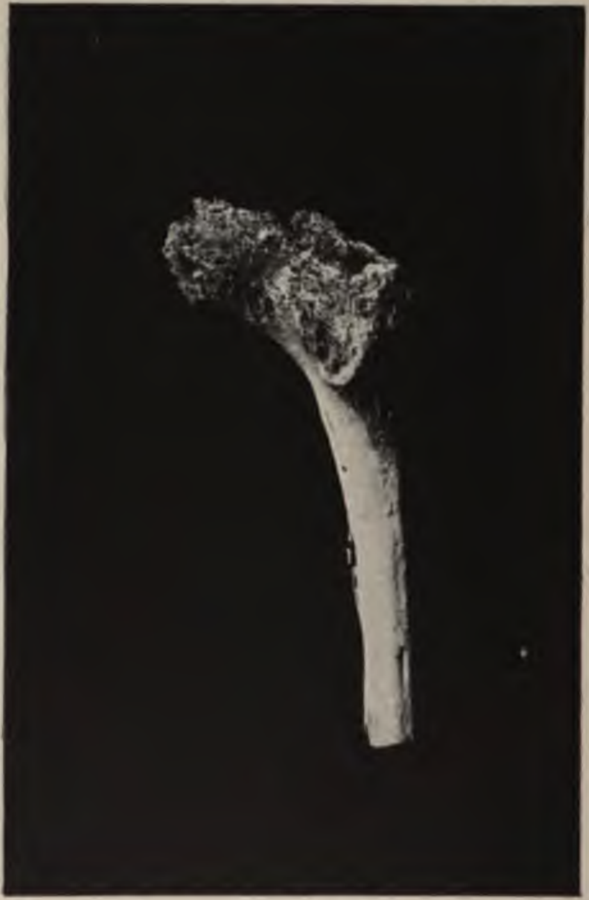


FIG. 525.—TUBERCULAR END OF FEMUR FROM A CHILD, SHOWING THE RAREFIED CONDITIO OF THE BONE.

gelatinous condition of the fibrous textures of the joint is not m œdema; the liquid cannot be squeezed out of the infiltrated pa It resembles more the state of the subcutaneous areolar tissue myxœdema. It is best seen in tubercular disease of the knee, elb and ankle joints.

When a section of the gelatinous membranes is made, small gr or sometimes yellow points are noticed lying in their midst. These prove on microscopic examination to be tubercles.

The soft parts of the joint may have become extensively tubercular before the cartilages show much alteration. In course of time, however, as the underlying bone substance begins to fungate, they ulcerate. Sometimes they are destroyed very early in the disease. Where the synovialis and capsule of the joint become tubercular and infiltrated, the condition is known clinically as **white swelling.**

Founding upon the fact that the synovialis is so much involved, it has been supposed that arthrodial tuberculosis usually commences within it. From this view Volkmann (No. 114, No. clxix., Chir. No. li.) early dissented. Although he does not deny (p. 1423) the existence of a primary tuberculosis of the synovial membrane, he holds that its frequency has been overrated, and that it occurs only in adults.[1]

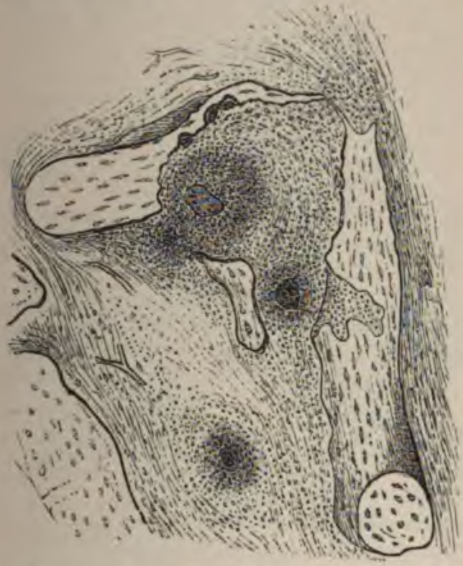


FIG. 526.—FUNGOUS INFLAMMATION OF KNEE-JOINT WITH RIGHT-ANGLE ANCHYLOSIS IN A YOUNG MAN. OLD TUBERCULAR NODULE IN THE TIBIA.

He states that the primary tubercular deposit is at first located in the end of the bone, and that the disease, consequently, in its commencement is an *osteopathy*, not an *arthropathy*. The deposit is often small and easily overlooked. The synovial membrane is secondarily infected from this primary focus.

---

[1] It should be mentioned, however, that recent statistics tend to raise the relative frequency of the primary synovial disease above what Volkmann supposed (see Cheyne, No. 6, 1891, i. p. 739 *et seq.*). All depends of course upon the thoroughness with which the parts are examined, a matter of no small difficulty, and the stage of the disease in which the examination is made.

The deposit in the bone corresponds in structure to tubercle elsewhere. It possesses giant-cells, is circumscribed, and has a tendency to caseate. The synovial membrane and neighbouring parts are bestrewed with tubercles, as aforesaid, and show sometimes a perfect reticular tubercle structure. The giant-cells are unusually large.

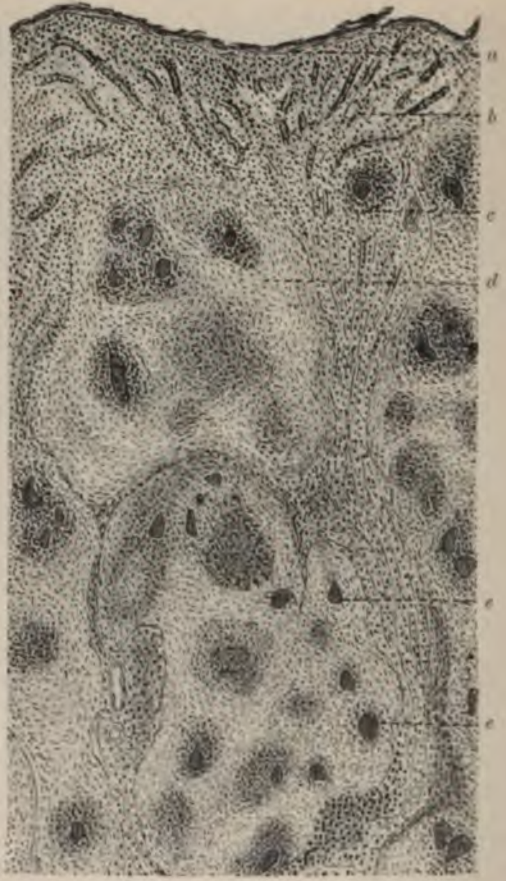


FIG. 527.—TUBERCULAR SYNOVIAL MEMBRANE FROM THE KNEE IN A CASE OF WHITE SWELLING (×50 DIAMS.)

(*a*) Endothelium in a state of catarrhal desquamation on the surface of the membrane; (*b*) blood-vessels with surrounding small-cell effusion; (*c*) small tubercle commencing to caseate; (*d*) larger tubercle; (*e*, *e*) giant-cells in same (Logwood, Eosin, and Clarified).

The fungous granulations projecting from the synovialis are well seen on placing the parts in water. They take origin in the villi of the synovial fringes. They have a red or pink colour and are peculiarly soft and œdematous. Each encloses a capillary loop, and around this is a quantity of granulation tissue. Pus is discharged from the vascular synovial surface which accumulates in the joint. In course of time it makes its way outwards through one or more sinuses, and the sinuses often have several external apertures. In the case of the knee such a sinus frequently opens into the popliteal space.

As a rule, the primary cheesy tubercular deposit in the head or neck of the bone softens and becomes converted into an abscess-like cavity. The pus from this makes its way outwards in different directions, or may burst into the joint.

In the latter case the cartilages give way, and the bare end of the bone protrudes directly into the cavity. The tissue round about the tubercular focus becomes luxuriantly vascular and is opened out, probably on account of the undue vascularity, so as to constitute a perfectly porous structure. In the case of the femur the head, and it may be the neck, of the bone are soon destroyed.

The other bones entering into the formation of the joint in course of time become infected. Most authors assert that in the case of the hip the disease commences in the acetabulum. Haberern (quoted by Cheyne, No. 6, 1891, i. p. 739) found that out of eighty cases where the disease was primarily located in the bone, in fifty it was confined to the acetabulum, in twenty-three to the head of the femur, and that it was present in both in seven. Cheyne states, however, that in his own cases those in which the disease was primary in the acetabulum were in a much lower proportion.

The line of infection is probably through the ulcerated cartilages. These may be destroyed either by an effusion underneath them or they may die as a result of a primary pyo-arthros. Volkmann supposes that in the latter case the tuberculosis has nothing to do with their death and removal. A suppurating joint from a penetrating wound, he says, will bring about a like disaster. They suffer absorption at several points, so that they come to present a sieve-like appearance.

Within the apertures, and it may be projecting from them, are masses of granulations connected with the underlying bone. Ogston (No. 5, x. 1875, p. 61) stated that the cartilage is actually converted into the granulation tissue by a proliferation of its cells. Fatty degeneration as a cause of absorption of the articular cartilages is not nearly so common as is generally supposed (Weichselbaum, No. 12, lxxv. Ab. III. H. 1-5, 1877, p. 228).

Future Course.—The destruction of the bone often leads to a true or pseudo-dislocation of its head; and the bone may become permanently fixed in a new position.

The disease, although tubercular, often has an inclination to subside, especially where the cheesy products have been discharged and the loose dead bone removed. This favourable termination is to be looked for more in children than in adults. Fibrous adhesions form around the ends and a ligamentous anchylosis completes the consolidation of the parts into what may be a comparatively serviceable limb. The limb, however, having lost one of its epiphysial connections, is always stunted, and in the case of the lower extremity often hangs as a useless appendage. There is comparatively little tendency to auto-infection, so that the subject of the disease may grow up into adult life and live out his or her strumous tendency.

Another result which is less satisfactory, and which is met with mostly in the case of the knee and elbow, is where the opened-out and denuded ends of the bone form an osseous anchylosis while the joint still remains tubercular.

The joint in such cases presents a rounded globose aspect. It is peculiarly blanched, the skin tense and elastic, and there may be several sinuses upon the surface. Some of these have probably healed, the cicatrix being deeply puckered, while others lie in the midst of a bluish pellicle of attenuated integument and are still open. Their margin is fringed by a ring of granulations, somewhat protuberant, and in the centre is a yellow spot, from which probably some curdy pus is exuding or can be pressed out, and which corresponds to the entrance into the sinus. A probe introduced into the sinus probably runs down to a rough piece of bone.

In the case where, for instance, the knee is the head-centre of the disease, it may be found that there are several additional sinuses, or their cicatrices on the leg or in the neighbourhood of the ankle. The muscles of the limb are wasted, and probably the ankle-joint extended from contraction of those of the calf of the leg. It is almost hopeless to expect that recovery will take place under these circumstances, and the sooner the limb is removed the better the prospects of ultimate relief.

The Sinuses.—These burrow deeply among the gelatinous structures surrounding the joint. They are fringed throughout their course by protuberant granulations, among which are numerous microscopic tubercle nodules.

Tubercular Disease of Vertebræ.—In children, tubercular disease of bone is most liable to affect the vertebræ and the bones of the hip, knee, ankle, and elbow joints. The shoulder joint is more often affected in adults.

In the case of the vertebræ the disease is in most instances located about the mid-dorsal vertebræ, sometimes in those of the lumbar and lower cervical regions, and frequently in the upper cervical.

The cheesy deposit takes up its stronghold in the body of the bone, and destroying its cancellous tissue, finally breaks through the outer hard shell. The softened cheesy material and broken-down bone substance push aside the ligamentous tissues lying in front of the spine, and thus construct an abscess sac. This may point in various situations, but often, under appropriate treatment, the contents dry and consolidate into an inert cheesy mass which is ultimately absorbed. The support of the vertebral column being thus removed by the destruction of one or more of its segments, the vertebræ above and below come into contact. In order to effect their junction, seeing that the portions of the vertebræ behind are still uninjured, the spine must curve backwards (Pott's curvature or kyphosis). It eventually becomes fixed in this position by ligamentous adhesions.

It is one remarkable feature of the tubercular affections of bone that they exhibit little tendency to bony reparation. The periosteum, for instance, does not tend to throw out osteophytes. The bones, consequently, do not exhibit irregularities on their surfaces after maceration from new bone having been deposited upon them. In fact there is seldom any attempt, even after years, at bony union between the adjacent surfaces of the vertebræ. The union in a large proportion of cases remains ligamentous. There is, indeed, no other disease of bone accompanied with so profound a disturbance of its economy in which there is so little show of reactive vitality.

When such an acute curvature as the above presupposes takes place, the spinal canal becomes always more or less constricted. Sometimes it is almost closed, a result of course accompanied by disastrous compression of the cord.

Literature on Tubercle and Caries of Bone and Joints.—**Black**: Edin. Med. Journ., iv. 1859, p. 780 *et seq.* **Cheyne**: Brit. Med. Journ., 1891, i. p. 739 *et seq.* **Cornil** (Tubercular): Arch. d. physiol. norm. et path., iii. 1870, p. 325. **Duret** (Fibrinous Synovitis and Tumor Albus): Bull. Soc. Anat. de Par., iv. 1879, p. 208. **Eve** (Caries): Trans. Path. Soc. Lond., xxxix. 1887-88, p. 266. **Friedländer**: Volkmann's Samml. klin. Vortr., No. 64. **Hueter** (Tubercular, Experimental): Ztschr. f. Chir., xi. 1878-79, p. 317. **König** (Miliary Nodules in Fungating Joints): Berl. klin. Wochnschr., viii. 1871, p. 229; *also*, Die Tuberculose der Knochen und Gelenke, 1884. **Krause**: Die Tuberculose der Knochen und Gelenke, 1891. **Laaf**: Ueb. d. entzündlichen Veränderungen des Knorpels bei Arthritis fungosa, 1879. **Macnamara**: Lancet, i. 1877, p. 561 *et seq.* **Oertel**: Beitrag. zur Aetiologie der fungöses Gelenkentzündung, 1880. **Ogston** (Cartilages in): Journ. Anat. and Physiol., x. 1875, p. 49. **Pawlowsky** (Experimental Production of Tubercular Joints): Ann. de l'Inst. Pasteur, vi. 1892, p. 116. **Phocas**: Tuberculoses localisées multiples, 1891. **Ranvier** (Disease of Cartilages): Bull. Soc. anat. de Par., xl. 1865, p. 701. **Redfern**: On Anormal Nutrition in Articular Cartilages, 1849. **Schüller**: Untersuchungen üb. die Enstehung und Ursachen der scrofulösen und tuberculösen Gelenkleiden, 1880. **Sonnenburg** (Tubercular): Arch. f. klin. Chir., xxvi. 1881, p. 789. **Vincent**: Internat. Encycl. of Surg. (Ashurst), vi. 1886, p. 901. **Volkmann** (Catarrhal Inflammation): Arch. f. klin. Chir., i. 1861, p. 408; (Caries) *Ibid.*, iv. 1863, p. 437; (Fungous Disease), Samml. klin. Vorträge, 1879, No. 168-169 (Chir. No. 51). **Walzberg and Riedel** (Tubercular): Deut. Ztschr. f. Chir., xv. 1881, p. 407. **Weber** (Disease of Cartilages): Arch. f. path. Anat., xiii. 1858, p. 74. **Weichselbaum** (Disease of Cartilages): Arch. f. path. Anat., lxxiii. 1878, p. 461.

ARTHRITIS.

1047. The recognition of the tubercular nature of strumous joint affections disposes of many varieties of arthritis which formerly swelled the nomenclature of joint pathology. The most of the non-tubercular varieties of arthritis are caused by septic disease, acute rheumatism, gout, gonorrhœa, or syphilis. They may also result from injury. Inflammation of the joints is likewise seen occasionally in connection with erysipelas, diphtheria, scarlet fever, dysentery, etc. There is one variety which is known as arthritis deformans or chronic rheumatic arthritis, and which requires special description. Those resulting from acute rheumatism, gout, and syphilis have already been referred to (see respective subjects).

Arthritis, from whatever cause, may assume two forms, namely: (1) where the synovial membrane is the exclusive seat of it, and (2) where the inflammation implicates the surrounding parts.

The first of these was likened by Volkmann (No. 92, i. 1861, p. 408) to a catarrh of a mucous membrane, and he gave it accordingly the designation of "Catarrhal Arthritis," or "Arthro-meningitis." It occurs in pyæmic and septicæmic conditions of body, in the so-named "cold abscess" of joints, in acute rheumatism, and in what is known as gonorrhœal rheumatism.

Fluid is effused from the inflamed membrane which at first may coagulate. It appears to be composed in great part of synovia. In other cases it is purulent, and Volkmann traces the pus in such cases mostly to a proliferation of the endothelium enveloping the membrane. The pus may be removed by absorption and the joint completely recover.

In the second or deep variety, in addition to the above modifications of the synovial membrane, abscesses develop in the capsule of the joint and its neighbourhood. They are almost always of septic (pyæmic) origin. The cartilages may perish as an effect of the presence of the pus in the joint. The pus may discharge itself from the joint into the surrounding soft parts. The vascular fringes of the synovial membrane, as in other forms of arthritis, become exuberant, and no doubt discharge inflammatory products into the joint.

The organisms of pyo-arthros seem to be identical with those of suppuration elsewhere. Krause (No. 43, xxi. 1843, p. 681) found a *streptococcus pyogenes* in acute catarrhal synovitis identical with that of Rosenbach.

Schüller (No. 92, xxxi. 1885, p. 276) alleges that where an arthritis follows a specific disease caused by a characteristic microphyte, such as pneumonia, erysipelas, or glanders, the specific organisms are present in the joint effusion only in small numbers, and are usually mixed with other organisms.

Literature on Acute Arthritis.—**Atkin** (Acute Arthritis in Infants): Med. Press and Circ., xxxix. 1885, p. 554. **Führer** (Inflammation of Joints): Arch. f. path. Anat., v. 1852, p. 129. **Huber** (Multiple Rheumatic Suppurative Arthritis in Children): Arch. f. path. Anat., lxxxviii. 1882, p. 246. **Krause** (Acute Purulent Synovitis): Berl. klin. Wochnschr., xxi. 1884, p. 681. **Martin**: Contribution à l'étude des arthrites septiques, 1885. **Schüller** (Bacteria in Metastatic Joint Affections): Arch. f. klin. Chir., xxxi. 1884, p. 276. **Traube** (Arthritis): Ges. Beitr. z. Path. u. Physiol., ii. 1871, pt. ii. p. 750.

SENILE CHANGES IN JOINTS.

1048. It is astonishing with what frequency the larger joints, such as the hip, are found diseased after death; and much has been written on the matter. Weichselbaum (No. 12, lxxv. Ab. III. H. 1-5, 1877, p. 193) had the opportunity of examining the joints in something like one thousand old people, and has carefully annotated the facts.

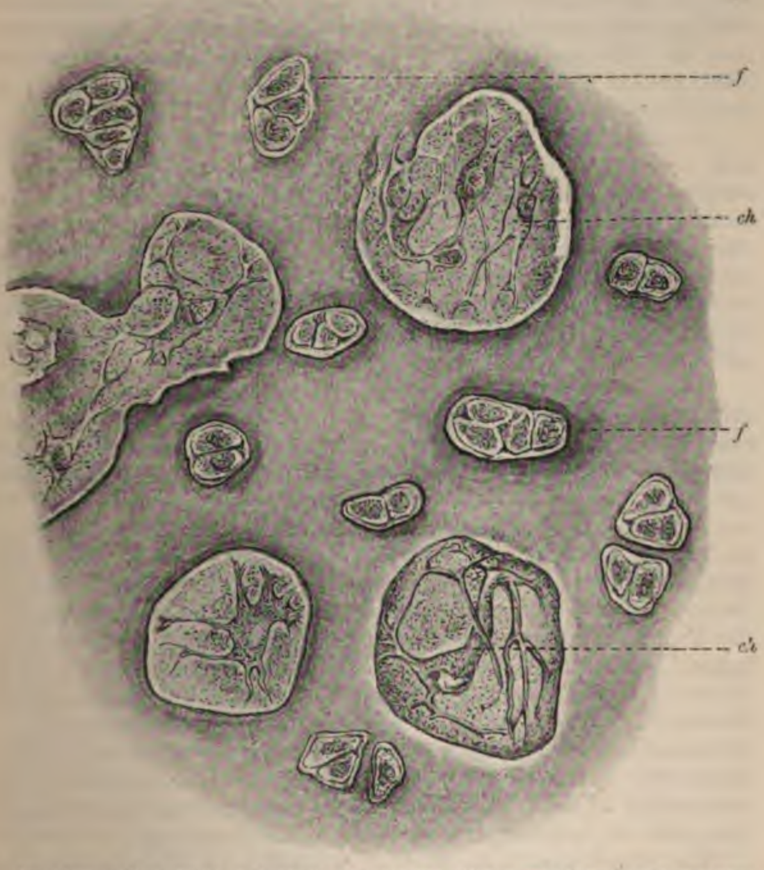


FIG. 528.—SENILE RESORPTION OF ARTICULAR CARTILAGE. HORIZONTAL SECTION TREATED WITH IODINE AND SULPHURIC ACID (Hartn., Obj. 8, Oc. 3).

(*f*) Young absorption spaces; (*ch*) young branched chondroclasts.

The part of the joint to suffer most in old people is the articular cartilage. It becomes fibrous, develops cracks or fissures on its surface, and becomes worn down in parts or completely removed. The bone lies exposed, and being subjected to undue friction, undergoes an ivory or porcelain-like hardening—an **eburnation,** as it is called. After the cartilage has vanished the bone surface may again become invested with a protective covering through a fibro-cartilaginous membrane spreading over it from the adjacent border of the synovialis or from the connective tissue in the underlying Haversian canals. Blood-vessels find their way on to the surface from the same sources.

The synovial membrane, however, also suffers severely. The vascular investment which replaces or covers in the defects in the cartilage may spread over the synovial membrane as well, in which case the villi projecting from its interior are increased in number. They assume the appearance of a deeply-injected corona around the articular surface.

A retrogressive process is often set up in the synovialis, and it may be in the new membrane covering the end of the bone. It consists in an opening out of the fibres of these parts, so that they become soft and gelatinous. If the synovial membrane is so attenuated that the underlying capsule of the joint is exposed, the capsule may assume the same appearances as the synovialis itself. Other fibrous or fibro-cartilaginous structures such as the teres ligament and tendon of the biceps may suffer in the same way as the articular cartilages, and may thus be entirely destroyed.

These changes in the cartilages and soft parts of the joint are of primary importance as bearing upon what is known as **chronic rheumatic arthritis** (arthritis deformans), as well as in relation to ulceration of cartilages generally. Indeed, what is termed "arthritis deformans" seems to be merely an extension of them.

Examined microscopically, the clefts in the cartilage above referred to become more apparent. They are represented by wavy lines mostly radiating from the capsules of the cartilage cells. These lines correspond to clefts in the cement substance binding together the fibrous bundles entering into the composition of the cartilage matrix. Later on, the matrix assumes a fibrous appearance from an extension of the same degeneration, and a viscid fluid permeates the interspaces. Coexistent with this the cartilage cells undergo proliferation, and the spaces within which they are contained enlarge. These two circumstances, the alterations in the matrix and the proliferation of the cells, taken together, cause the cartilage to become thickened—a condition sometimes known as hypertrophy.

The new-formed cells, however, according to Weichselbaum (*loc. cit.* p. 218), have little vitality and rapidly succumb by suffering liquefaction. They do not become fatty. The remaining spaces then collapse.

The cartilage, having become fibrous, is easily worn away and absorbed. There is another means, however, by which this absorption may be effected; it takes place from the periphery inwards and appears to be something akin to the absorption of bone. The cartilage capsules enlarge, and several of them fuse together so as to form a space. This space becomes occupied by branched cells derived from the neighbouring synovialis. Later on, the branches disappear and the cells come to resemble ordinary cartilage cells. They lie in a fibrous basis, so that the texture filling the space has the appearance of fibro-cartilage. The defects in the cartilage are most evident at its margin. They have a close resemblance to the Howship's lacunæ seen in absorbing bone. The cells which penetrate into them act as chondroclasts. In what way they effect the absorption of the cartilage is not certain. Weichselbaum thinks it most likely that they disturb the cartilage matrix mechanically by pressure.

ARTHRITIS DEFORMANS.

1049. *Syn.*—Chronic Rheumatic Arthritis, Arthritis nodosa, sicca, spuria, or rheumatica, Arthroxerosis, Arthrite sèche, Polyarticuläre Arthritis, Rheumatic Gout. In the hip it is known as Malum Coxæ Senile.

From the perusal of the preceding section it will be gathered that in old people the joints are frequently diseased, and that the defect consists in an absorption of the cartilages and a condensation of the exposed bone.

Weichselbaum (No. 12, lxxv. Ab. III. H. 1-5, 1877, p. 240) regards the disease we are now considering simply as a higher grade of these senile degenerations. This view, however, it is only right to mention, has been opposed by Volkmann and other authorities.

It has often been supposed to be associated with rheumatism. There is doubt, however, as Wilks (No. 192, iv. 1858, p. 61) long ago remarked, whether it has anything to do with this disease, at least with what is usually designated acute rheumatism or rheumatic fever.

It has also been asserted to be of gouty origin, but, as already shown in describing the subject of gout, there is little cause for concluding that there is any such connection.

The disease seems to possess many of the characters of a chronic arthritis, but what the exciting and maintaining causes of this chronic inflammation are has not been satisfactorily explained. A disease, in most of its features, identical with that in Man, is found in the lower animals, such as the horse, subjected to heavy work. In Man it is more prevalent, from all accounts, in those who have laboured heavily than in others whose occupation has been of a less arduous character.

There appear to be two varieties. In one of these (polyarticular) many joints are afflicted from the first; in the other (monoarticular) the disease commences in one joint and may afterwards spread to others. The polyarticular begins in the small joints of the fingers and toes and spreads centrally; the monoarticular starts from a large joint, such as the hip, and spreads peripherally (Senator).

The large joints most often the seat of it are the hip, shoulder, and elbow ; and another very common site is the vertebral column.

Changes in the Joints.

Polyarticular Variety.—The cartilages become eroded, while the synovial membrane is thickened and otherwise altered by proliferation of its cells. The two exposed surfaces of the bone come in contact and unite by a fibrous anchylosis. The hand and fingers assume a peculiar position, which, for the most part, is characterised by a predominance of flexion over extension. The phalanx of the fingers is extended and the last phalangeal joint is flexed so as to cause a claw-like appearance of the member ; the wrist is usually flexed. The affected joint feels sometimes like a "bag of bones," from there being small pieces of detached newly-formed bone within and around it.

Monoarticular Variety.—One of the earliest alterations noticed in the joint (*e.g.* hip) is an erosion of the cartilages. They vanish apparently by becoming resolved into fibrous tissue and by becoming absorbed by chondroclasts. The connective tissue of the synovialis and capsule of the joint proliferates, and a low type of cartilage is here and there deposited in the substance of these membranes. Ossification next commences within the thickened soft tissues of the joint, the result being that much new bone is thrown out, sometimes as a large mushroom-like mass, at other times in small semi-detached islands. The ligamentum teres or tendon of the biceps, as the case may be, suffers absorption like the cartilages.

Later on, the cup of the joint assumes a flattened-out appearance, so that it becomes much shallower than in health, while round about it are the irregularly-shaped new growths of bone. The joint looks (Wilks, No. 192, iv. 1858, p. 62) as if some soft plastic substance had been placed between the ends of the bones and squeezed out, and had undergone subsequent solidification. The head, and it may be the neck, of a long bone may become in great part absorbed, so that in the case of a bone like the femur the end of the shaft with the excrescences around it lies almost sessile upon the shallow acetabulum. The acetabulum and remains of the head of the bone may in course of time become united by a soft vascular new tissue, or an osseous synostosis may take place. If not actually united, the surfaces of the bones suffer eburnation.

In the case of the spine new bone is thrown out upon the bodies of the vertebræ in the form of very irregularly-contoured osteophytes. These may be so extensive that they unite the one vertebra inseparably to the other (spondylitis deformans ; *σπόνδυλος*, a vertebra). Occasionally the pelvic joints are similarly implicated.

The minuter changes in the bone, as described by Ziegler (No. 13, lxx. 1887, p. 502), do not in all respects bear out the title of the disease to be ranked as an inflammation. The most striking feature, he remarks, and more especially is this so when the bone is in progress of absorption, is the presence within it of cyst-like cavities. These lie sometimes in the neighbourhood of the cartilages, at other times at some distance from them. In many instances they appear to be surrounded by a membrane. He accounts for them by the bone of the part losing its characters and reverting to cartilage. Islands of cartilage are found scattered through the bone tissue, and having no connection with the surface of the joint. These cartilage islands in course of time soften and give rise to the above cyst-like formations. This reversion of bone to cartilage seems to be a peculiar feature of the disease.

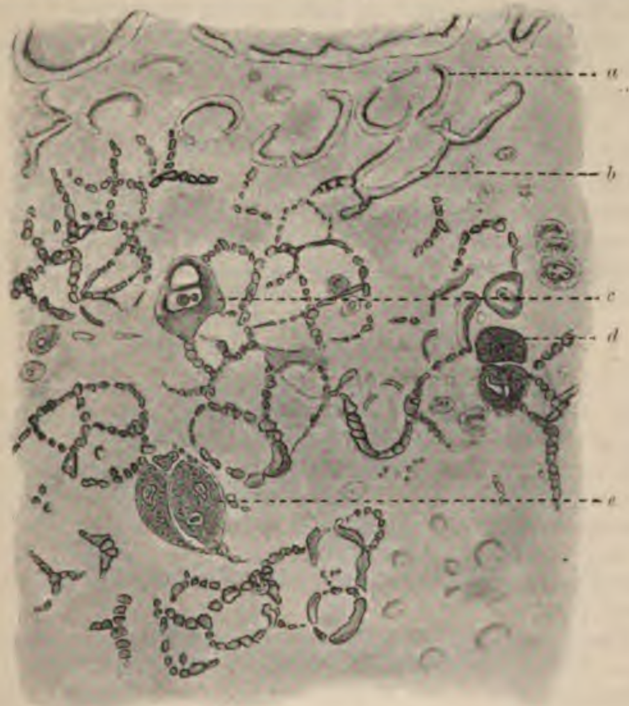


FIG. 529.—AMYLOID DISEASE OF CARTILAGE OF HEAD OF HUMERUS (Hartn., Obj. 8, Oc. 2).

(*a*) Completely degenerated cartilage cell; (*b*) cartilage cell commencing to degenerate; (*c*) amyloid cell capsules run together while the cell substance has disappeared; (*d*) fragment of a degenerated capsule; (*e*) completely degenerated cell in which the amyloid has assumed a granular appearance.

Literature on Arthritis Deformans.—**Arthritis Deformans, etc.:** Samml. klin. Vortr., 1884, No. 233 (Chir. No. 75), p. 2041. **Canton** (Chronic Rheumatic Arthritis): Trans. Path. Soc. Lond., iii. 1880-82, p. 153; *Ibid.*, xii. 1860-61, p. 162; *Ibid.*, xiii. 1861-62, p. 270. **Garrod:** A Treatise on Gout and Rheumatic Gout, 1876. **Hitzig** (Arthritis Deformans): Berl. klin. Wochnschr., ix. 1872, p. 638. **Krebs** (Rheumatic Inflammation in Oxen): Arch. f. wissensch. u. prakt. Thierheilk., xi. 1885, p. 71. **Little** (Chronic Rheumatic Arthritis): Trans. Path. Soc. Lond., xi. 1859, p. 285. **Virchow** (History Arthritis Deformans): Arch. f. path. Anat., xlvii. 1869, p. 298. **Weichselbaum** (Arthritis Deformans): Arch. f. path. Anat., lv. 1872, p. 217; *also*, Sitzungsb. d. k. Akad. d. Wissensch., Wien, lxxv. 1877, p. 193. **Wilks** (Chronic Rheumatic Arthritis): Guy's Hosp. Rep., iv. 1858, p. 61. **Ziegler** (Subcartilaginous Changes in Arthritis Deformans): Arch. f. path. Anat., lxx. 1877, p. 502.

WAX-LIKE DISEASE OF JOINTS.

1050. A very common lesion found in the cartilages and synovial membranes of old people is the above. The amyloid is deposited mainly in the wall of the capsule enclosing the cartilage cell; according to Weichselbaum (No. 12, lxxv. Ab. III. H. 1-5, 1887, p. 229), the cell itself is the primary seat of it. The deposition by preference affects those cartilages, or parts of them, which are suffering absorption.

CALCIFICATION OF THE ARTICULAR CARTILAGES.

1051. This is another common senile condition. It may be microscopic in its extent, in which case the cartilage capsules are the sole recipients of the lime salts; or it may extend more widely through the matrix. It might be mistaken readily for a gouty deposit of urate of soda.

LOOSE CARTILAGES IN JOINTS.

1052. These are comparatively common in the knee and wrist joints. They are sometimes single, more frequently multiple. As many as fifty have been removed from a knee joint (see case by Berry, No. 6, 1890, ii. p. 958), and even a larger number are frequently found in the wrist. They vary in size and shape, sometimes button-like, at other times resembling melon seeds or boiled rice.

They usually possess a fibrous capsule, are in great extent composed of cartilage, and have often a small nucleus of cancellous bone at some part.

Their origin is as follows:—The synovial membrane and its fringes, it will be remembered, contain cartilage cells. The villi upon the inner surface of the membrane often become enlarged as a result of an arthritis. Their naturally dendritic arrangement becomes exaggerated, and their club-like extremities hard, from a new formation of cartilage within them. The attachments of these terminal buds become more and more attenuated until a separation is effected. The detached mass does not perish, but is nourished by the fluid of the joint. It becomes moulded subsequently by friction into the particular shape it assumes. They must not be mistaken for the loose fragments of bone around the joint so often found in chronic rheumatic arthritis.

As bearing upon their vascular origin it should be mentioned that the fluid expressed from the joint, if withdrawn early, may be found to be much blood-stained (see case by Beatson, No. 5, xiii. 1879, p. 449), while the bodies in question are absent. Later on, the fluid becomes clear, and a large number of loose cartilages may be evacuated.

Poulet and Vaillard (No. 4, v. 1885, p. 298) state that rarely these bodies take their origin from pieces of detached articular cartilage, or even from the articular head being accidentally loosened.

Literature on Loose Cartilages in Joints.—**Berry** (Fifty Loose Cartilages): Brit. Med. Journ., 1890, ii. p. 958. **Filter:** Ueb. solitäre Lipome des Kniegelenkes u. ihre Ursache, 1890. **Klein** (Loose Cartilages): Arch. f. path. Anat., xxix. 1864, p. 190. **Paget** (Loose Cartilages): St. Barth. Hosp. Rep., vi. 1870, p. 1. **Patteson** (Joint Bodies): Journ. Anat. and Phys., xxiv. 1889-90, p. 360. **Pichon:** Des corps étrangers intra-articulaires, 1890. **Poulet and Vaillard** (Loose Cartilages): Arch. de physiologie norm. et path., v. 1885, p. 266.

LIPOMA OF SYNOVIAL MEMBRANES.

1053. The same vascular fringes, which are productive of so much mischief in the joint, when they enlarge, instead of becoming cartilaginous, occasionally assume the characters of lipomata. The fat cells which they naturally contain, proliferate. An exuberant villous mass of fatty tumours from this cause comes to protrude into the joint. When single, these tumours may become detached and constitute a movable foreign body in the joint.

TUMOURS OF BONE.

1054. These are chiefly spindle and giant-cell sarcomata, hyaline chondromata, osteomata, secondary carcinomata, fibromata, etc. Fibro-chondromata grow from the capsules of joints, while hyaline chondromata generally grow from bone, not from cartilage. The hyaline variety has a great tendency to ossify; the osteoma is usually a chondroma to begin with.

These tumours have all been described formerly (vol. i., *Tumours*).

BURSAL ACCUMULATIONS—HYGROMA AND GANGLION.

1055. By a **hygroma** (ὑγρός, moist) is understood an accumulation of clear and, it may be, serous fluid in one or more of the bursæ mucosæ. When the liquid is gelatinous and, possibly, blood-stained, the term **ganglion** is applied to the swelling. The difference in the character of the liquid has more pathogenetic significance than might at first be supposed.

These true ganglia are found on the foot, elbow, and neighbourhood of the knee. They always have gelatinous, not serous contents. The liquid of a hygroma is a mere dropsical effusion; the liquid of true ganglia is a secretion from the wall of the sac.

The ganglia have been supposed to be distended sheaths of tendons or diverticula from synovial membranes, and the fluid has been held to be synovia. Virchow named the condition "hygroma ganglioides" or "tumor synovialis" on this account.

They are seldom seen in old people. In the case of the wrist, in which locality they are perhaps commonest, they lie on the back

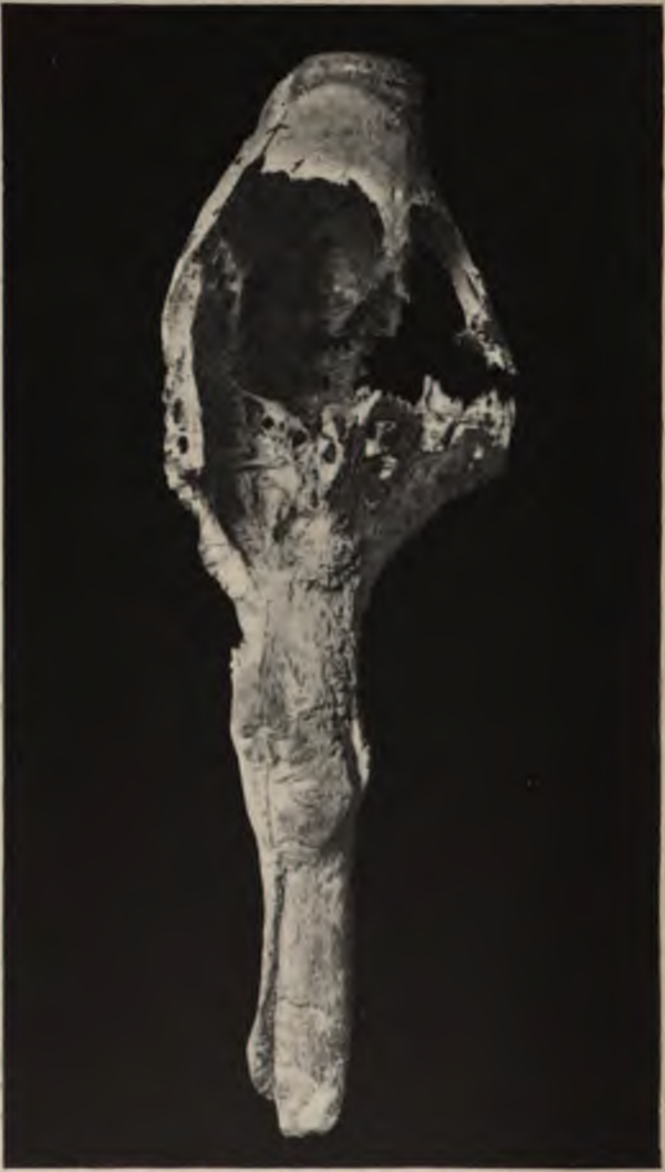


FIG. 530.—TIBIA WHICH HAD BEEN THE SEAT OF A SARCOMATOUS TUMOUR. SHOWS THE ABSORPTION AND OPENING OUT OF THE BONE.

of the hand or close by the radial artery. In the latter situation the sac protrudes between the *supinator longus* and the *flexor carpi radialis*. The artery runs over or near the tumour. That on the dorsum manus shows itself in the space between the *extensor indicis proprius* and the *extensor carpi radialis brevis*. In rare cases it lies between the *extensor carpi radialis brevis* and the *extensor pollicis longus* (Falkson).

According to Falkson (No. 92, xxxii. 1885, p. 58), the wall of the sac is usually bound to the sheaths of several tendons. In eleven out of thirteen cases examined by him it was ascertained that there was an absence of any communication with the wrist joint; in the remaining two the relationship could not be determined. A free communication with the joint, he says, may in all cases be put out of the reckoning, and if fluctuation of the joint is felt, it must be due to the pressure of the sac upon the joint capsule. The sac can always be traced up to the capsule, but within his experience does not communicate with it.

He asserts that they are neither prolongations of synovial membranes nor bursæ of tendons; he thinks that they are the result of a degeneration of the synovial follicles described by Volkmann, or of the so-called sub-synovial bodies described by Henle and others.

As alleged by Hoeftmann, they are probably to be regarded as synovial dermoid cysts. Hence their intimate connection with the capsule of the joint.

PARASITICAL DISEASES OF BONE.

1056. The chief of these are Hydatids and Actinomycosis. They are described under Animal and Vegetable Parasitical Diseases respectively.

CLUB-FOOT (see *Malformations*).

CURVATURE OF THE SPINE.

1057. **Nomenclature.**—The posterior curvature (Pott's), technically known as **cyphosis** (κύφωσις, a hump-backed person) or **cyrtosis** (κυρτός, curved), arising in connection with tubercular absorption of the bodies of the vertebræ, has already been described (p. 854).

Lordosis (λορδόω, I bend) is the term applied to an anterior curvature. It is generally due to rickets, especially when in the lumbar region. **Scoliosis** (σκολιόω, I twist) and **hybosis** or **hyboma** (ὗβος, the hump of a camel) are terms which were formerly and still are in use to indicate a lateral curvature.

A common cause of lateral curvatures is undue muscular development on one side of the body, as in persons habitually using the right arm. Lateral curvatures are also met with in persons of weak muscular development. The chief deforming element in them is the weight of the head. This presses directly upon the ill-supported spinal column and throws it into a lateral curve.

SPONDYL-OLISTHESIS.

1058. By this is meant a condition in which there is a solution of continuity, either congenital or acquired, of the neural arch of the fifth lumbar vertebra, allowing of a prolapse of the portion of the spine above this forwards and downwards into the pelvis. The condition is often the result of fracture. Some cases have been held to be due to caries of the bone, but these seem to be rarer than is supposed. The hip bones become unusually prominent, and a characteristic deformity results. The spinal canal need not necessarily be obliterated. The disease was first described by Kilian in the year 1858, and some of the most noted cases are reported by Neugebauer in his monograph on the subject (No. 582, 1888).

GENERAL LITERATURE ON PATHOLOGY OF THE BONES AND JOINTS.

Adams: Brit. Med. Journ., 1869, i. p. 70 *et seq.* **Brodie**: Path. and Surg. Observations on Diseases of the Joints, 1818. **Bryant**: On the Diseases and Injuries of the Joints, 1859; *also*, Med. Times and Gaz., 1869, i. p. 622. **Cooper**: A Treatise on Diseases of the Joints, 1807. **Coote**: On Joint Diseases, 1867. **Holmes**: Syst. Surgery, iii. **Jones**: A Treatise on Bone Diseases, 1887. **Lane**: Trans. Path. Soc. Lond., xxxv. 1883-84, p. 299. **Ollier**: Internat. Encycl. of Surg. (Ashurst), vi. 1886, p. 843. **Schreiber**: Atlas der Gelenkkrankheiten, 1883.

DISEASES OF THE TEETH.

Dental Caries.

1059. Of all the diseases of the teeth, so-called caries is that which is by far the widest spread among different races, and is the most frequent cause of their destruction. The inhabitants of all countries seem to suffer from it, some perhaps more than others. Arab races, the Esquimaux, North American Indians, African savages, and, generally speaking, uncivilised races as a whole, however, suffer comparatively slightly from the disease. It is one which appears to increase in frequency the higher the state of civilisation which prevails. It is a disease which, moreover, has affected primitive races of Mankind, as can be seen from the skulls in any anthropological collection. The female sex is subject to caries in a distinctly higher proportion than the male. The lower animals seldom contract it.

Its onset is characterised by an opaque spot upon the enamel either of a masticating surface or of a depression on the crown. This often opens out into a fissure-like erosion, while the opaque spot becomes more or less discoloured, the tint varying from an ash-gray to a deep brown. It is now pretty widely acknowledged that this fissured condition is brought about mechanically by the solvent action of an acid either contained in the diet or generated in the alimentary *viæ*. *Lactic acid* has a powerfully solvent action on enamel.

Its surface having thus become denuded, micro-organisms of various kinds find their way into the dentine tubes, cause them to widen, and bring about their destruction (see Underwood and Milles, No. 264, iii. 1881, p. 523; and Miller, No. 573). The discoloration, according to Miller, is due to the presence of chromogenous micro-organisms (*e.g.* bacillus fuscans) as well as to the sulphuretted hydrogen of the putrefying pulp acting upon the iron of the tooth.

Simple Erosion.

Simple erosion of the surface is common both in children and adults. It consists in the scooping out of minute cup-shaped cavities often located on the labial aspect of the tooth without the ordinary symptoms of caries. These erosions are sometimes of considerable size. They pierce through the enamel down to the dentine. The erosion tends, however, to be arrested and not to involve the vitality of the tooth.

Syphilitic Teeth.

Hutchinson (No. 610, i. 1866, p. 317) called attention to a peculiar deformity of the permanent teeth the result of inherited syphilis. The upper central incisors are those most typically affected. These teeth are more or less peg-shaped and very thin. After a while a crescentic segment breaks away from their edge, leaving a notch which is permanent for some years, but ultimately becomes worn down.

Other Diseases of the Teeth.

Apart from periosteitis, suppuration of the fang, and so on, the teeth sometimes uffer from the accretion of an excessive layer of *cementum* around their roots. It forms an exostosis-like growth. In some instances a huge **odontoma** grows from the formative pulp and may press upwards into the antrum. In horses these tumours are common enough, and consist of an irregularly-contoured mass of dentine sometimes with an admixture of enamel or bone. Supernumerary teeth are often met with. Dentigerous cysts may form in the jaws and occasionally extend up into the antrum. They seem to arise in connection with the teeth, and may even have teeth lying within them.

Literature on Diseases of the Teeth.—**Black**: American System of Dentistry. **Harris**: Principles and Practice of Dentistry, 1889. **Leber and Rottenstein**: Ueb. d. Caries d. Zähne, 1867. **Magitôt**: Recherches sur la carie des dents, 1871. **Miller**: Die Mikro-organismen der Mundhöhle, 1889; *also*, American Transl. 1890. **Milles and Underwood** (Caries): Trans. Internat. Med. Cong., Lond., 1881. **Mummery** (Caries): Trans. Odont. Soc., Gt. Britain, ii. 1870, p. 7; *also* (Preparation of Teeth and Bone), Brit. Journ. Dent. Sc., xxxiii. 1890, p. 578. **Sewill**: Student's Guide to Dental Anatomy and Surgery, 1876. **Tomes**: Syst. Dental Surgery, 1887.

CHAPTER XC

DISEASES OF THE SKIN

PIGMENTED CONDITIONS OF THE SKIN.

1060. THE skin becomes more or less universally bronzed or of a mulatto-tint in **Addison's disease.** The term **chloasma** (χλοάζω, I am pale green) is one of generic significance applied to pigmentation diffusely spread abroad, or localised to patches, and occurring on the face or other parts of the trunk. By *C. uterinum* is meant the pigmentation of the areolæ of the nipples and of the linea alba in pregnancy and sometimes in diseased conditions of the uterus. *Ephelides* or *freckles* are due to brown pigmentation, caused, like other forms of pigmentation, by deposit of pigment in the rete Malpighii. The application of counter-irritants, or the exposure of the skin to unusually great heat, induces a brown pigmentation. The dappled brown colour of the front of the legs seen so frequently in old subjects has been alleged to be caused by exposing the legs to the heat of the fire (Ephelis ignealis). Many eruptions leave a pigmented condition of the skin after they heal.

The pigment is found most abundantly in the rete Malpighii, but the papillary layer underneath is also coloured. In Addison's disease the coloration of the cutis vera is well marked. In fact the rete cells seem to get their pigment at second hand from that contained in the fibrous tissue of the cutis.

Pigmentation is sometimes brought about spuriously by the excessive use of *silver* (argyria), *arsenic*, *picric acid*, and other poisonous substances. *Tattooing* is another form of spurious coloration.

PITYRIASIS RUBRA (Hebra).

1061. By *Pityriasis* (πίτυρον, furfur, bran) the older writers understood several varieties of dermatitis in which fine scales are thrown off in varying quantity. Most of these, however, are now considered to represent simply phases of particular skin diseases of wider range, such as eczema; while others, such as P. versicolor, are known to be caused by a vegetable micro-parasite.

Pityriasis rubra, however, seems to be quite a special disease, and according to Hebra (No. 616, ii. p. 69), who gave it this name, was mentioned by Bateman in his continuation of Willan's work.

Hebra applies the name to an affection in which, throughout its whole course, the only symptom is the *persistent deep-red coloration of the skin.* The colour becomes arterial red when the individual is warm, as in bed, more of a purple when cold. Throughout the entire progress of the malady there are neither papules nor vesicles; there is an absence of all abnormal secretion and of fissures; and the condition of redness affects the whole surface of the body.

The disease is a rare one and generally proves fatal. The patient falls off in flesh and in energy; the skin becomes pale and yellow tinted towards the fatal termination.

ERYTHEMA (*ἐρύθημα, redness of skin*).

1062. **Definition.**—The term *Erythema* is employed by most dermatologists in a somewhat generic sense to indicate *a class of diseases characterised by patchy redness of the skin, with more or less effusion into its superficial layers.* Many of the diseases so classified are considered to be the result of an *angeio-neurosis.*

Theory of Angeio-Neuroses.—As detailed by Kaposi (No. 615, p. 299), this is briefly as follows: His explanation is an extension of that given originally by Eulenburg and Landois. Firstly, a contraction of the small arteries in a limited area of the papillary layer of the skin takes place by stimulation of the vaso-constrictor nerves, or in virtue of the protoplasmic vitality of the capillary walls. To this succeeds, secondly, a period of relaxation of the wall and dilatation of the channel, followed by hyperæmia and slowing of the blood current. The relaxation results from paralysis of the vaso-constrictors or stimulation of the vaso-dilators.

In a first class of examples the angeio-neurosis goes no further. It is characterised simply by temporary redness of the skin without effusion of blood-products. Such are the roseolar eruptions of *measles, syphilis,* etc.

In a second class, however, not only is there vascular dilatation, but this dilatation is accompanied by effusion of serum, so that, in addition to the affected patch being red, it is also infiltrated and raised. Such, for instance, appears to be the state of the parts in *erythema nodosum* and in *urticaria.*

In a third class, not only is serum effused into the skin, but this serum forces itself beneath the epidermis and forms vesicles or bullæ.

As examples of such, the vesicular stages of erythema exudativum multiforme may be cited.

In accounting for these angeio-neurotic manifestations, we must suppose that some stimulus is applied to the nerve mechanism concerned, either centrally or peripherally.

Thus (1) it is comprehensible that the vaso-motor centres in the medulla may be acted upon directly by the poisons of, let us say, measles, syphilis, scarlatina, typhoid, etc., in such a manner as to bring about the vascular dilatation which is the cause of the eruption.

(2) We may suppose further that stimuli applied to the periphery may influence these centres reflexly.

(3) The centres in the higher brain exerting an influence over the blood-vessels may be excited directly or reflexly, and bring about an arterial dilatation as in ordinary blushing.

(4) Apart from any nerve impulse propagated from the great nerve centres, there is reason to believe that stimuli applied to the skin may act locally upon the vessels of the papillary layer. Thus the thumb-nail drawn sharply across the skin causes a line of blanching, followed in a few seconds by a corresponding line of redness. And in some individuals so great is the susceptibility to pressure thus exerted, that not only a line of redness is forthcoming, but a distinct wheal of raised and serum-infiltrated tissue, like that of urticaria, makes its appearance a minute or two after the redness has become visible. This does not seem to be a reflex effect of the stimulus applied, but rather a purely local reaction of the vessel walls. It is probably alike with that which follows the poisonous stings of insects, which, it will be remembered, are also followed by great œdema.

It is questionable whether the effusion into the skin in this class of diseases is to be regarded as inflammatory, even although it sometimes contains small round cells. It has more the character of a local dropsy. The border-land between the two, however, is not well defined.

The *outward manifestations* of such angeio-neuroses vary according to the presence or absence, and the amount of this effusion. Thus if there be an absence of effusion, the part may present the appearance simply of a *rose-red or purple-coloured patch.* Should there be a small amount of effusion, a *papule or tubercle* may follow. Should this be greater, it may conform in appearance to a *wheal.* While, if the exudate undermine the epidermis, a *vesicle or bulla*, according to the amount, may be the result.

The order, however, is always the same, namely, that of macula, papula, tuberculum, vesiculum, and bulla, in accordance with the amount of the effusion; and all or any of these may be manifestations of what may be called an erythematous affection. In keeping with this, several forms of erythematous disease are generally described. They are chiefly as follows:—

(1) *Erythema Exudativum Multiforme* (Hebra).

Syn.—Erythema Polymorphe (Kaposi).

The disease gets its name from the many aspects it assumes, passing, as it may do, from a mere roseolar eruption into one which is distinctly vesicular.

It occurs symmetrically and usually on the backs of both hands and feet, as well as on adjacent parts of the forearms and legs. It shows first as minute spots or maculæ of cinnabar-red congestion, from a pin's head to a lentil-seed in area. These enlarge, and as they do so tend to coalesce. They lose their red colour under pressure, are flat or elevated, œdematous or hard, as the case may be, and may possess a sharp border. They are widely disseminated, and while one crop partly loses its colour and fades, a fresh crop appears in the parts above. After a few hours each macula becomes depressed in the centre and cyanotic, while the younger periphery still retains its cinnabar-red tint. The increase in size goes on until each patch may come to be as large as a crown-piece. These finally run together, so that possibly by the second or third day the eruption on the back of the hands has become diffuse. It has a purple colour. If present in the face the eruption may still have a discrete character, and at parts, as on the eyelids, there may be punctiform hæmorrhages, which in course of time suffer discoloration.

It sometimes happens that the centre of the patch becomes unusually pale, the margin remaining red. To such the name **Erythema annulare** is given. Where several of these coalesce they constitute patches with an irregular or sinuous border. This condition is known as **Erythema gyratum or figuratum.** If a red spot appears in the centre of an otherwise pale patch, the term **Erythema iris** is applied to it. Should a little nodule form where previously there was only a congested spot, the condition is called **Erythema papulatum**; and if the patch be raised but larger than a papule, something like an urticaria wheal, it is known as **Erythema urticatum** or **Lichen urticatus.** If the effusion into the skin be greater and the liquid undermine the epidermis so as to form vesicles, the term **Erythema vesiculosum** is applied to it; and if the vesicles be multiple and located at the margin, that of **Herpes circinatus.** Sometimes in the vesicular variety a single vesicle is seen at the centre, a circlet of vesicles at the periphery. This is known as **Herpes iris.** One vesicle at either the margin or the centre may be unusually large, and to this form the name **Erythema bullosum** is given.

The exudation, after the vesicles have atrophied, may dry and be converted into crusts. The disease usually terminates in scaling, and leaves a brown pigmented mark at the affected part.

As a rule, there is little if any fever accompanying the condition, but complications such as peri- or endocarditis, pleurisy or pneumonia, may arise and may prove fatal.

(2) *Erythema Nodosum* (*Urticaria tuberosa*).

This disease is characterised by the occurrence of congested and elevated masses of skin varying in size from a hazel-nut to a walnut, and usually situated upon the legs and back of the feet, to a less extent upon the forearms, thighs, and nates. They are of hard consistence, of a cyanotic tint at the centre, brighter red at the margin. On account of their hardness they are easily felt, but are unusually painful on pressure. They sometimes run together, at other times are disseminated. There may be from fifteen to twenty of such patches upon one extremity, and one lot may vanish to be replaced by another, a phenomenon which may continue for weeks or months.

Their appearance is usually accompanied by fever, and they are looked upon as in some way connected with derangements of the organs of digestion.

Anatomically, the thickening is found to be caused chiefly by serous infiltration of the fibrous texture of the skin and subcutaneous areolar tissues, together with great congestion of the blood-vessels. In all respects the mass resembles a gigantic urticaria wheal.

(3) *Roseola.*

The term is strictly applied to a measly rash occurring mostly in infants or young children. It is also employed, however, to indicate the patchy congestion of the skin characteristic of measles, syphilis, scarlatina, typhoid, etc. A similar rash follows upon the excessive consumption of copaiba, quinine, opium, iodine, bromine, etc.

It is essentially a condition of almost pure hyperæmia. There is little if any effusion into the parts around.

Other forms of Erythema are **E. fugas,** where the redness is of a transitory and patchy character. It comes out suddenly on the face and trunk, and disappears in from a few minutes to a few hours. **Chilblains** (pernionides) are a variety of erythema brought on by frosty weather. They commence as erythematous patches, which rapidly become infiltrated. They excite excessive itching and it may be pain. They sometimes become much inflamed when exposed to friction and may ulcerate or slough. In the first stage of the disease known as **Pellagra,** a disease occurring chiefly in Northern Italy and Spain, an erythematous eruption shows itself on the back of the hands, on the face, neck, and breast. **Acrodynia** or **E. endemicum** is characterised by the occurrence of an erythematous efflorescence, something like that of pellagra. It is located on the hands and feet. In the years 1827-29 it spread epidemically over Paris and several other French towns. Since then it has been observed occasionally among French and Belgian soldiers. The term **E. læve** is used to indicate the erythematous eruption occurring upon œdematous limbs.

URTICARIA (*urtica*, a nettle).

1063. As before said, this is another of the so-called angeioneuroses. It is characterised by the breaking out of congested wheals upon different parts of the body, and is usually connected with some gastric disturbance. The eating of certain articles of diet serves to bring out an eruption of nettle-rash in some persons.

ERYSIPELAS (ἐριυσίπελας, from ἐρυθρός, *red*, and πελλα, *the skin*).

Syn.—St. Anthony's Fire, The Rose.

1064. **Definition.**—*A contagious and sometimes epidemic disease, characterised by acute inflammation of the skin, or of a mucous membrane, and to a certain extent of the subcutaneous areolar tissue, tending to spread over a wide area from a limited centre, and usually ending in resolution from the eighth to the thirteenth day. The inflammation is due to a specific microbe, the Streptococcus Erysipelatis.*

Starting Point of the Disease.—The inflammation usually originates in a wound; it may be a lacerated wound of the scalp, or a mere crack or fissure in the skin. At other times not even an abrasion is visible. So that the disease is sometimes described as traumatic and idiopathic.

Seats.—The skin of the face and scalp enjoys a pre-eminence in point of frequency; that of the arm or upper arm probably comes next. The cicatrising umbilicus serves occasionally as the centre of the infected area (erysipelas neonatorum); while in rare instances the mucous membrane of the pharynx and nares is the part primarily invaded by the specific coccus. Puerperal fever, so called, seems in many cases to be caused by the same parasite as that of ordinary erysipelas. The vagina, uterus, and peritoneum are the seats of its growth and ramifications. The liquid taken from a puerperal peritonitis teems with the microbe. These puerperal cases may or may not be accompanied by some cutaneous manifestation of erysipelas. Erysipelas may also follow vaccination, or spread from an old ulcer.

Vital Phenomena.—Ordinary cases are ushered in with shivering. A painful area of a reddish-brown colour, and perhaps from half a crown to a crown-piece in size, develops upon the skin. In the case of erysipelas of the face the initiatory seat of the inflammation is often the nose and its neighbourhood. The inflamed part, over and above being painful, is also itchy at first. On the following day the blush of redness has perhaps spread over a much wider area, and in from three to five days the disease has reached its acme.

The affected part is now much swollen and of a brownish-red colour. It pits on pressure, and presents a peculiarly brawny hardness on being touched. Vesicles or bullæ filled with serous fluid may force themselves up on the surface (erysipelas vesiculosum or bullosum), or actual pustules may form in certain cases (erysipelas pustulosum). The constitutional phenomena are severe. The evening temperature rises to 39°-41° C. and the individual is usually delirious.

The part then becomes softer, more and more brown-coloured, and scales or flakes of brown epidermis peel off. The vesicles dry down, and the topical manifestations of the disease undergo resolution. As a rule, very little induration of the part remains, but it may happen rarely that the skin assumes a pachydermatous aspect or a permanent œdema takes hold upon it (erysipelas œdematodes).

There is a variety in which the disease spreads by long shoots or processes of inflammation (erysipelas migrans or erraticum) which attack fresh territories as the old areas heal; and to such an extent may this proceed that the whole surface of the body may become successively invaded. Patches of erysipelatous redness may even again show themselves in the parts which have healed.

Occasionally, although seldom, the disease ends in phlegmonous suppuration (erysipelas phlegmonodes) or in gangrene (erysipelas gangrenosum).

Anatomical Changes.—The cause of the brawny hardness and tension of the skin is the large amount and the diffuse spreading of the inflammatory exudation. The part is full of serous liquid and fibrinous precipitate. Leucocytes are abundant around the blood-vessels; and it is said that the fixed cells of the part proliferate. Doubt is thrown on this latter statement by some, but the fact that the skin may remain permanently thickened in certain cases shows that the connective tissue has been stimulated.

The specific coccus is found at the margin of the blush of redness, not in parts where the inflammation is of older standing (Lukomsky, No. 13, lx. 1874, p. 418). And here, as shown by Koch (No. 44, i. 1881, p. 38), it is confined to the lymph-spaces and lymph-radicles; it does not infiltrate the blood-vessels. The blood in most cases seems to be free from it (Wolff, No. 13, lxxxi. 1880, p. 193), but thrombus-like masses of coccus have occasionally been found lying in the vessels of internal organs (v. Recklinghausen, Billroth, Lukomsky).

So abundant is the infiltration of the lymph-spaces that, as shown in Fig. 531, a complete injection of these may be presented to view. Billroth, indeed, described erysipelas as an inflammation of the skin in which the irritant causing the inflammation spreads through the network of cutaneous lymph-vessels. Kaposi calls it a "lymphangioitis capillaris."

The coccus sometimes invades the lymphatics of the subcutaneous areolar tissue, but never to the same extent as those of the corium itself.

Many of the cocci are seen enclosed in the protoplasm of ambulant phagocytes, never, according to Baumgarten (No. 595, p. 230), in fixed cells.

The rete Malpighii of the epidermis becomes vacuolated and opened out into a trellis-work-like structure. The cause of this is its infiltration with effused liquid, and sometimes the effusion is so great that vesicles or bullæ, as already described, are forced up on the surface. These bullæ contain the coccus only sparingly, so sparingly that

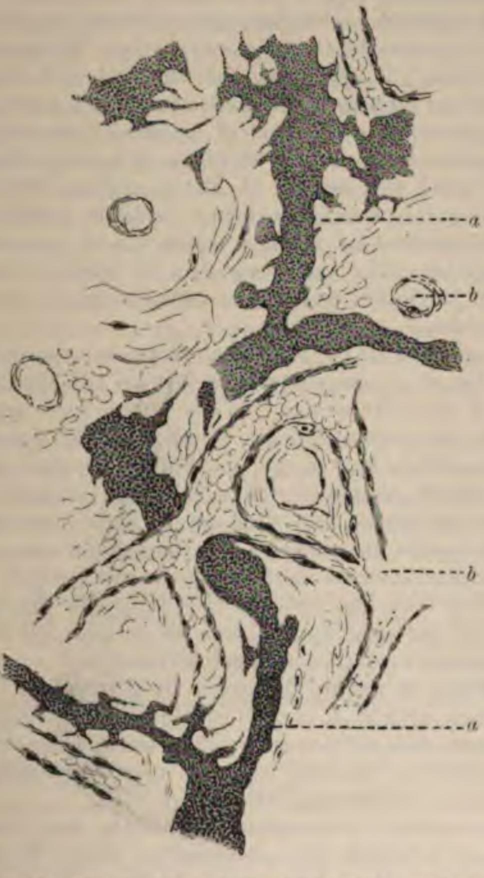


FIG. 531.—HORIZONTAL SECTION OF THE SUBCUTANEOUS AREOLAR TISSUE FROM A CASE OF HUMAN ERYSIPELAS (Hartnack, Oc. 3, Ob. 8).

(*a*, *a*) Lymph-vessels filled with micrococcus; (*b*) blood-capillaries in neighbourhood containing blood but no coccus.

the liquid may fail to communicate the disease when inoculated (Wolff).

The small-cell infiltration found around the blood-vessels also invades the root-sheaths of the *hair*. Hence the hair tends to lose its hold and to fall off. The *sebaceous glands* are similarly the subject of a small-cell infiltration.

The Microphyte.—Fehleisen (see collected papers in No. 612) was the first to isolate the coccus of erysipelas. He obtained it from the inflamed skin. It appears to be identical with the *Streptococcus pyogenes* found by Passet and Rosenbach in abscesses, although till lately, and even yet, there was a difference of opinion on this subject. It takes the form of a sinuous chain or rosary, the individual members of the chain being round and not all of like size. Even when thus strung together there is a tendency for them to hang in couples (diplococci). They are easily stained by ordinary methods, and are not decolorised by Gram's process. The same organism is found in the lochial discharge, and in the liquid within the peritoneum of women suffering from puerperal fever.

It grows on most media, with the exception apparently of potato. It will develop at a temperature as low as 16°-18° C., but a body temperature is more favourable. When a puncture inoculation of a tube is made, the colonies begin to show along the track of the needle within twenty-four hours, but only sparingly. In about four days the characters of the growth may be well studied. It loses its virulence in a few weeks, and dies out in about four months. The track of the needle in nutritive gelatine shows fine white round colonies. Similar colonies show on the surface, which in due time run into a white scale-like film. It never liquefies the gelatine. On agar very much the same appearances are noticed. It is particularly virulent when taken from a puerperal peritonitis.

The organism is readily destroyed by germicides. After a few seconds' contact with a 1 per mille solution of corrosive sublimate, or a little longer with a 3 per cent solution of carbolic acid, its vitality has gone. After ten minutes' exposure to a temperature of 52°-54° C., it likewise dies (Sternberg, No. 613, p. 276).

If a pure culture is inoculated upon the ear of the rabbit, it causes localised erysipelatous inflammation, which in the course of thirty-six to forty-eight hours extends to the root of the ear. Subcutaneous injections do not usually cause erysipelas; they often indeed prove quite harmless, or at most end in calling forth a phlegmon. Similarly intravenous injections fail to excite erysipelas, and may not elicit any symptom of note. Implanted in the cornea, it spreads between its laminæ in a characteristic fashion.

Inoculated upon Man, a pure culture calls forth a characteristic erysipelas. It has been frequently inoculated upon Man with the view of arresting the growth of ineradicable tumours such as lupus, cancer, etc., and even with the object of removing syphilides (Busch, Volkmann, Fehleisen, Janicke, and Neisser). It has been said that these tumours cease to grow and suffer retrograde degeneration when a natural attack of erysipelas ensues in their neighbourhood, and it has been alleged that on several occasions a salutary result has followed the excitation of such an erysipelas artificially. But the practice has never become generalised, owing to the danger accompanying it.[1]

Of seven individuals suffering from tumours and inoculated by Fehleisen (No. 612), six took erysipelas. The seventh had suffered from an attack of erysipelas of the face two or three months before, and proved to be immune. It is said that salutary results follow only where the coccus wanders abundantly into the tumour structure.

Cause of sudden Cessation of Disease.—When the attack of erysipelas has reached its height the fever rapidly declines, and the coccus vanishes from the inflamed part. Several theories have done duty to account for this. One, upheld by Metchnikoff (No. 13, cvii. 1887, p. 209), is, that the phagocytes engulf the parasites and destroy them—the theory of phagocytosis. Another is that the high temperature at the climax of the disease kills them. De Simone (No. 614, Nos. viii. and xii.) found that a pure culture was deprived of vitality on being subjected to a temperature of 39·5°-41° C. for two days.

Infectiosity.—The coccus of erysipelas in its natural habitat is probably a saprophyte. It adheres to particles of dust, and may be conveyed by means of them from one host to another. It has been found by Eiselsberg and Emmerich in the atmosphere of a surgical ward notorious for the number of erysipelas cases occurring in it.

Literature on Erysipelas.—**Achalme**: L'érysipèle, 1893. **Billroth**: Coccobacteria septica, 1874. **Critzman** (Érysipèle a Répétition): Arch. gén. de méd., 1892, i. p. 24. **Dénucé**: Étude sur la pathogénie et l'anatomie patholog. d. l'Erysipèle, 1885. **v. Eiselsberg** (Erysipelas Cocci in Air): v. Langenbeck's Arch., xxxv. **Emmerich** (Erysipelas Cocci in Air): Vers. Deut.-Naturf. u. Aerzte zu Berlin, 1886, p. 433. **Fehleisen**: Aetiologie des Erysipels, 1883. **Flügge**: Die Mikro-organismen, 1886. **Fraenkel**: Grundriss der Bacterienkunde, 1887. **Galliard** (Staphylococcus Arthritis of Knee in case of Erysipelas of the Face): Bull. et mém. Soc. méd. de hôp. de Paris, ix. 1892, p. 438. **Hüter**: Grundriss d. Chirurg., 1880. **Knoor** (Identity of Streptococcus Pyogenes and S. Erysipelatis): Berl. klin. Wochnschr., xxx. 1893, p. 699. **Koch**: Mittheilungen a. d. kaiserl. Gesundheitsamte, i. 1881, p. 38. **Lukomsky**: Arch. f. path. Anat., lx. 1874, p. 418. **Metchnikoff**: Arch. f. path. Anat., cvii. 1887, p. 209. **Nepveu**: Des bactéries dans l'érysipèle, 1870 and 1885. **Orth** (Experimental): Arch. f. exp. Path. u. Pharmakol. i. p. 81. **Passet**: Untersuchungen üb. die eitrigen Phlegmonen des Menschen, 1885. **Pfuhl** (Case of General Infection with Streptococcus following Cutaneous Erysipelas): Ztschr. f. Hyg. u. Infectionskrank, xii. 1892, p. 517. **Roger** (Experimental Study of Streptococcus of Erysipelas): Rev. de méd., xii. 1892, p. 929. **De Simone** (Relationship of a Form of Pyæmia to E.): Morgagni, 1885, Nos. 8-12. **Wolff**: Arch. f. path. Anat., lxxxi. 1880, p. 193. **Ziegler**: Naturforscherversammlung in Salzburg, 1881.

---

[1] In this relationship it may be mentioned that the late Mr. Syme observed an indolent ulcer of the leg take on a remarkable healing action after a localised attack of erysipelas, an observation which led him to adopt the practice of applying a blister to such ulcers, with, as is admitted, the very best remedial effect.

ECZEMA (*ἐκζέμα, a heat spot;* from *ἐκζέω, I boil over*).

1065. This is often described as a catarrhal affection of the skin, from the fact that it resembles catarrh of mucous membranes. The disease usually runs an acute course, but in certain subjects, more especially those of lowered vitality, it tends to become chronic and intractable.

Vital Phenomena.—It is characterised firstly by more or less redness of the skin, accompanied by itching. Next an eruption of papules occurs upon the part, followed by vesicles or pustules, from which there exudes a viscid watery discharge; the papillary layer, and sometimes the entire depth of the corium, become thickened. Scabs or scales form on the surface, which on falling off leave the skin in a comparatively healthy state, although generally somewhat brownish coloured. The parts of the body most frequently affected are the face, hands, and interdigital spaces of the toes, auditory meatus or nares and their vicinity, the folds of the groin, nates, external genitals, etc.

Terminology.—Various terms are applied to particular forms of eczema according to the dominant peculiarity of the case. Thus those of *E. papulosum or lichen simplex*, *vesiculosum*, or *erythematosum* are used to indicate that the disease inclines to the papular, vesicular, or œdematous infiltrated and congested type. *E. pustulosum* or *impetiginodes* is that variety in which pustules instead of papules or vesicles are present; *E. rubrum* or *madidans*, where the inflammation is intense; *E. squamosum*, where the inflammation is slight, and where there is a psoriasis-like tendency to desquamation. The term *Intertrigo* is applied to the excoriated condition resulting from the close apposition and friction of two adjacent skin surfaces.

Morbid Anatomy.—Little or nothing is known of the true pathology of many of the varieties. Some of them are said to be reflex angeio-neuroses, and to be closely related to the erythemata.

The papillary layer of the corium is that which is most affected. It presents evidence of inflammation in the presence of a small-cell infiltration of its interfibrillar spaces, and liquid exudation. In the papillary variety the papillæ are swollen The greater the intensity of the inflammation the deeper the small-cell infiltration spreads into the corium, and it may be into the subcutaneous fat. The epidermis becomes opened out and undermined by the exuded liquid, as in any other vesicular lesion of the skin.

IMPETIGO (a scabby eruption; from *impetere*, to assail or attack).

1066. This in olden times was the generic term for a pustular eruption. Most of the forms of impetigo, however, prove to be simply varieties of eczema (*E. pustulosum*).

There is one variety, notwithstanding (*I. contagiosa*), which is generally held to be a special disease, and, as its name indicates, the impression is that it can be communicated from one individual to another. It starts as an eruption of vesicles on various parts of the body, which in course of time become converted into pale yellow-coloured pustules. Several microphytes and even moulds have been isolated from the contents of the pustules, but probably these are to be regarded more as evidence of contamination than as the specific cause of the disease.

Ecthyma (*ἔκθυμα*, a pustule) appears to be simply a variety of this disease occurring on the trunk or limbs, and distinguished by the affected part possessing an inflamed basis. The inflammation is probably the result of friction.

VESICULAR SKIN DISEASES.

1067. There are certain affections of the skin characterised essentially by the vesicular efflorescence accompanying them. The more prominent members of the group are Pompholyx, Herpes, and Pemphigus. The *miliaria* or *sudamina* appearing in feverish states of the body are to be reckoned in the same category. They appear to be simply localised portions of epidermis undermined by sweat.

(1) *Pompholyx* (*πομφόλυξ, a water-bubble*).

The term is applied to an eruption of bullæ or blebs, devoid of an inflammatory basis and unaccompanied by fever, in which the blebs are located upon the hands and feet, and vary in size from a millet to a nux-vomica seed or larger. They do not rupture spontaneously, but tend to dry up and be absorbed. The liquid they contain, according to Crocker (No. 617, p. 136), is neutral or alkaline and perfectly clear at first, although that in the older ones is turbid.

The vesicle, according to the same authority, is usually hollowed out in the midst of the rete of the epidermis, and often in the course of a sweat duct.

(2) *Herpes* (*ἕρπω, I creep*).

Definition.—By herpes is understood a transitory eruption of one or more vesicles occurring upon a congested base, and either independently or as an accompaniment of some other disease, such as acute pneumonia, intermittent fever, typhoid, gonorrhœa, etc.

Varieties.—There are several varieties, but the most important are H. labialis or facialis, H. zoster, and H. progenitalis or preputialis.

Herpes labialis has been already described (see p. 445).

Herpes zoster (ζωστήρ, a belt) or shingles is characterised by the eruption of vesicles occurring usually on one side of the trunk, but it may be on the face or elsewhere. The vesicles may come out successively; they are surrounded by a halo of redness, and their appearance is accompanied by great pain. The vesicles contain clear serum at first, which becomes milky later on and ultimately may be purulent. It vanishes in course of time, but leaves distinct scars at the points where the vesicles have existed.

It is said that the eruption, wherever situated, follows the course of a cutaneous nerve, so that the view is generally entertained that herpes is a skin disease essentially under the domination of peripheral nerves—that it is, in fact, one of the angeio-neuroses; and this is borne out by the fact that the intercostal or other nerves concerned are found to be in a state indicative of inflammation. The disease in fact looks as if it were a peripheral neuritis accompanied by serous effusion into the epidermis. Sometimes the nerve lesion seems to be central, and then the motor fibres may participate in the neuritis as well as the sensory. A paralysis from this cause may ensue in the course of the disease.

The nerves most commonly involved are the intercostals and the fifth. It is stated by Robinson (No. 620, p. 231) that a small-cell infiltration, a perineuritis, sometimes prevails around the nerves of the subcutaneous areolar tissue, and that this small-cell infiltration may be seen to follow the finer branches.

Herpes progenitalis is a vesicular eruption occurring upon the prepuce, glans penis, labia, or even on the cervix uteri. The vesicles are small and aggregated, and are resident upon a somewhat congested basis. It usually follows some time after the cessation of a gonorrhœa or the healing of a soft chancre. If irritated, as by the act of coitus, the surface may become abraded and the condition mistaken for one which is chancrous.

(3) *Pemphigus* (*πέμφιξ, a bubble*).

The vesicles are larger than in any of the other vesicular skin diseases mentioned. They vary in size from a pea to a small orange, and are filled with clear serous liquid at first blood-stained and turbid, but becoming, it may be, purulent later on.

In **P. vulgaris** the disease commences with the appearance of erythematous spots or patches, followed possibly by urticaria-like wheals. The vesicles raise themselves upon these erythematous patches, upon the wheals, or it may be upon the neighbouring unchanged skin. The appearance of the eruption is preceded by feverish symptoms characterised by shivering, high temperature, and quick pulse.

In from two to six months the disease suffers resolution. The vesicles dry down into scabs, which after being shed leave a brown-pigmented basis of skin. The fever vanishes and no further eruption of vesicles is noticed. In other cases, however, the epidermis shed with the drying down of the blebs is not reproduced and the raw surface extends (**P. foliaceus**). The corium may become involved, and a gangrenous slough take place. Granulations may subsequently show themselves on the denuded part.

Pemphigus is occasionally a disease of infancy, and, when so, is almost always *syphilitic*. The vesicles are situated on an inflamed basis, and when they rupture or are opened the floor seems red and almost granulating.

The pathology of the disease is still unknown. It is neither contagious nor hereditary.

Formation of the Vesicles.

In all these varieties of skin disease the mode of formation of the vesicles is alike. A vesicle is essentially a collection of serous liquid embedded and encapsuled within the epidermis. Its development commences usually within the rete Malpighii. The serous liquid stretches the surrounding epidermic cells, and forcing its way between certain of them, gives rise to the formation of a number of cavities. Those cells constituting the walls of the cavities become vacuolated and die, and when this happens the vesicle may be found to consist of a single space, or at most of one with a limited number of loculi. Pus cells possibly migrate or are forced out from the adjacent papillary layer of the derma, causing, at first, a turbidity of the contained liquid, later on, a complete transformation of it into pus.

PSORIASIS (*ψωρίασις, a being itchy or mangy*).

1068. The essential appearances of a psoriasis eruption are patches of varying size, consisting of a congested basis with red papillæ, which bleed on being roughly handled. This red basis is covered with white scales or flakes of dead epidermis. The eruption is unaccompanied by discharge of any kind from its commencement to its termination. The colour of the congested cutis is bright red at first, becoming duller later on. It is a chronic and in some cases a peculiarly intractable disease, so much so that the term **P. inveterata** has been applied to one variety. In these old-standing cases the masses of dead epidermis are prolific, and sometimes, becoming mixed with inspissated half-purulent material, assume a rupia-like aspect (P. rupioides, M'Call Anderson, No. 618, p. 310). This rupia-like affection, however, does not show an ulcerated base when the crust is removed, as ordinary rupia does.

Several varieties are described, chief of which are the following:—

P. guttata and **punctata**, in which the patches are of small size, in the former discoidal, in the latter more papilliform, and each covered by a characteristic scale of white epidermis. In **P. nummularis** patches the size of a half-crown to a crown-piece, rounded and disc-like, prevail. Occasionally the patch assumes a ring-like (**P. circinata**) or gyrated (**P. gyrata**) outline. The outbreak in

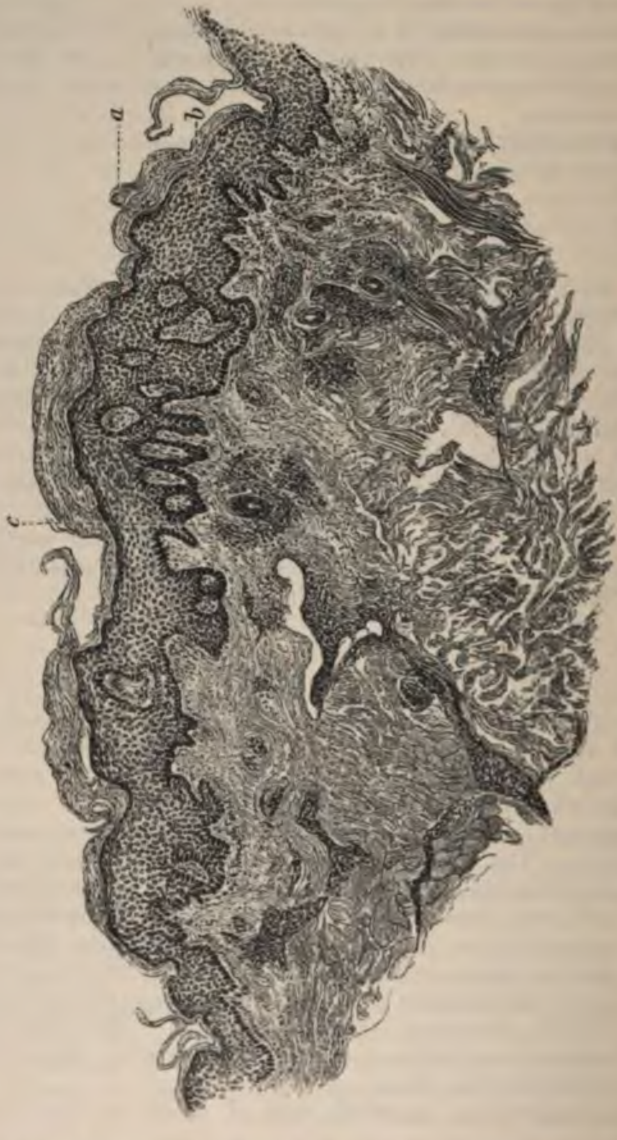


FIG. 332.—VERTICAL SECTION OF PRIMARY NODULE OF PSORIASIS EXCISED DURING LIFE.

(*a*) The thickened horny layer of epidermis; (*b*) the rete enlarged through swelling of its cells without manifest proliferation; (*d*, *e*) base of nodule with cellular accumulation (*c*) round the blood-vessels of the papillæ.

some cases, instead of being limited to small patches, spreads over wide areas (P. diffusa).

The eruption may be limited to particular regions, such as both palms of the hands (P. palmaris), or to one only. Similarly it may show itself on the soles of the feet. In other instances it may cover the greater extent of the surface of the body (**P. universalis**).

Morbid Histology.—As pointed out by Robinson (No. 619, xxviii. July 1878; *also*, No. 620), the essential point in the morbid histology of psoriasis is the *increase in the depth of the rete Malpighii.* So great is this that the appearance resembles that of a commencing cancer. The interpapillary portion is where the accumulation of the rete cells is greatest, and on account of this the papillæ appear particularly long. The rete covering the papillæ is said to be unusually slender (Thin), hence the exposed surface is liable to bleed. Overlying the altered rete are the psoriasis scales, composed of dead horny epidermis. The death of the cells forming these scales takes place, according to Thin (No. 6, 1881, ii. p. 147), in the prickle-cell layer of the rete—that is to say, in the layer which immediately overlies the somewhat cylindrical cells adjacent to the corium. The cells here become vacuolated and lose their nuclei, and being cast off rapidly, increase the bulk of the already abundant but badly constituted horny epidermis, and thus give rise to the scales.

The vessels of the derma suffer congestion, and the derma itself becomes thickened through being infiltrated with small round cells.

Nature of Disease.—It has often been supposed that psoriasis is a parasitical disease. There is no distinct evidence, however, of its being contagious, nor has any specific microphyte ever been cultivated from it. It is often hereditary, and there is some slight evidence to show that it is communicable. Lassar (No. 43, xxii. 1885, p. 771) asserted that he had conveyed it to rabbits by applying psoriasis scales, lymph, and blood to the skin. The observations of Angelucci, Lang, and Wolff on the parasitical nature of the disease are not sufficiently far-reaching to be conclusive.

ICHTHYOSIS (*ἰχθύα, the dried rough skin of the shark*).

1069. There are many degrees of ichthyosis described, but in all of them the essential characteristic is a dry and spiny roughness of the surface. This varies from a mere harshness up to a condition in which the papillæ become converted into bodies like small porcupine quills.

Xeroderma.—In this there is a mere harshness and dryness of the skin, distributed generally over the body. The term **tylosis** is applied to a condition of this kind limited to the palms of the hands and the soles of the feet. Sometimes the outer aspect of the upper arm is the seat of this roughness. It may be that the harsh epidermis accumulates around the minute hairs, and the two together give rise to

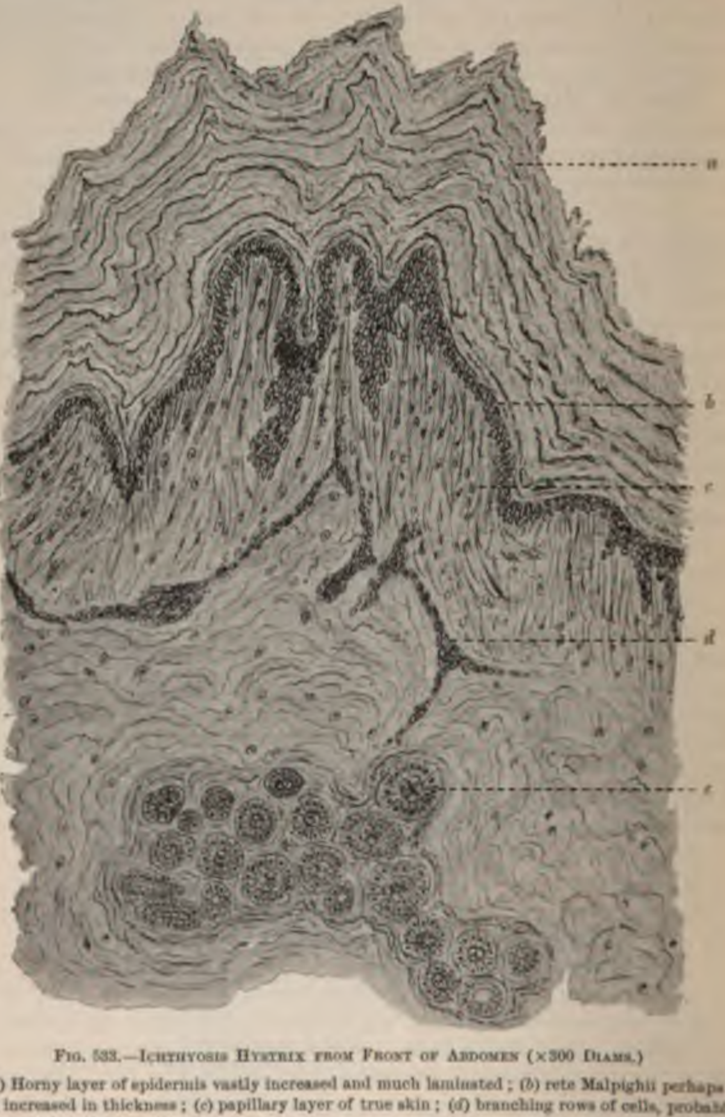


FIG. 533.—ICHTHYOSIS HYSTRIX FROM FRONT OF ABDOMEN (×300 DIAMS.)

(*a*) Horny layer of epidermis vastly increased and much laminated; (*b*) rete Malpighii perhaps a little increased in thickness; (*c*) papillary layer of true skin; (*d*) branching rows of cells, probably obliterated lymphatics; (*e*) sweat-gland.

spine-like projections. This is known as **lichen pilaris**, and is described under *lichen*.

Ichthyosis Simplex.—All the varieties of true ichthyosis come on in early childhood. They are alleged to be congenital and hereditary, but there is some doubt of this being the case. It is generally about the second year that the disease makes its appearance. It spreads, according to all accounts, from a central focus, and manifests itself more or less generally over the body, especially on the skin of the abdomen. It forms crocodile-scale-like excrescences on the surface. The papillæ in these are not unusually prominent. They seem to be caused rather by a general thickening of the horny layer of the epidermis and cutis vera. The altered epidermis has a sebaceous secretion bound up with it which tends to bind the cells of the part into a compact armour-like mass. The skin, it should be mentioned, also becomes very tight, so that the child may be unable to cry.

One peculiar variety of what seems to be the same disease occurs at birth in what is known as the "Harlequin fœtus." Several of these fœtuses are contained in London Museums. One which the author had an opportunity of examining was exhibited by Mr. Bland Sutton some years ago to the London Pathological Society. The fœtus is born, as it were, ensheathed in a complete casing of scaly armour. There is a continuous covering of hard material fissured in a wonderfully symmetrical manner by interlacing cracks into polygonal scale-like areas. From the examination of the skin from this same case Crocker (No. 617, p. 294) comes to the conclusion that the incrustation was not a mere deposit of vernix caseosa of unusual thickness and hardness, but was due to enormous thickening of the horny layers, the cells mixed with fatty matter just as in I. hystrix.

In **I. hystrix** the papillæ are so elongated as to cause an appearance of quill-like bristles projecting from the part. They have a brownish colour, and are hard and spiny to the touch. All the layers of the epidermis are prolific, but on the surface the horny layers have accumulated to an inordinate extent (Fig. 533). The blood-vessels of the cutis vera may be dilated and filled with blood, and the lymph-vessels in a state of lymphorrhœa. The cutis vera does not seem much altered.

The pathology of this, as of so many other skin diseases, is quite unknown.

RUPIA OR RHYPIA (ῥύπος, *sordes* or *filth*).

1070. This is essentially a syphilide usually showing itself in the third stage of the disease, although sometimes it is noticed earlier.

A bulla, the contents of which may be clear or blood-stained, develops upon a congested basis. It ruptures and the contents escape. The interior continues to discharge, and the exuded liquid dries and forms a crust. This crust accumulates and becomes a conical, stratified, and rough projection like a limpet shell. At the same time that the incrustation is gathering, the basis of skin on which it is located begins to ulcerate, so that by the time the crust separates a punched-out ulcer presents itself. The ulcer may even show itself before separation by projecting beyond the margin of the crust.

DISEASES OF THE SEBACEOUS GLANDS.

1071. The sebaceous glands, it will be remembered, are acinous in their ramifications and mostly open by a duct into a hair follicle. If the adjacent hair is very fine, if it belongs to the lanugo type, it may happen that it projects into the duct of the gland before emerging upon the surface. The largest glands are found in the skin of the nose and in the labia; the skin of the palm, of the vola manus, and of the planta pedis is alone devoid of sebaceous glands. They are lined by epithelium which secretes the fatty material or *sebum*.

(1) *Seborrhœa* (*sebum*, *suet*, and ῥέω, *I flow*) or *Steatorrhœa* (στέαρ, στέατος, *fat*).

By this is understood either a condition in which the sebaceous secretion is so altered that, becoming mixed with epidermis, it tends to accumulate in scale-like particles on the surface of the scalp and other parts of the body; or one in which the sebum is secreted in too great quantity, and is expressed upon the surface in the form of minute drops. The **vernix caseosa** of the fœtus is an accumulation of sebum and shed epidermis, and that which occurs in the adult is simply a recurrence of this in a limited degree. The condition of seborrhœa in the scalp sometimes takes the form of dandruff or scurf. Bran-like scales are thrown off in abundance of a gray or yellow colour. This is usually looked upon as a dry seborrhœa. The excessive secretion and desquamated epithelium may accumulate in the hair follicle to such an extent that they compress the hair and cause it to fall off prematurely.

In the oily form of the disease the skin is unusually glossy, from the excess of fatty matter on the surface.

(2) *Sebaceous Cysts or Wens.*

These consist of sebaceous glands distended with more or less altered secretion. They vary in size from a millet seed up to that of a hen's egg, and are found mostly on the scalp and skin of the trunk. They are usually soft and doughy, but if inflamed may become much harder. Those on the trunk are seldom larger than an almond, and are somewhat flattened out and blanched in appearance. In the centre is seen not unfrequently a minute black point like that of a comedone. It is the obstructed mouth of the sebaceous gland implicated. In the case of wens of the scalp, the wall of the sac is thick, and the sac is readily drawn out on being incised and the contents evacuated.

These contents consist of a thick putty-like substance made up of fatty matter, epithelium, cholesterine crystals, and, it may be, abortive hairs. The odour emitted by the contents of sebaceous tumours located on the skin of the trunk is sometimes extremely fœtid.

A wen, it should be remembered, occasionally proves the starting-point of a cancer, and care should be taken consequently to remove the entire sac.

(3) *Acne* (*ἄκνη, quasi, ἀκμή, a point*).

This is a very common and often troublesome affection, occurring mostly from the time of puberty on to that of thirty years. It consists in the occlusion and subsequent or coexistent inflammation of the sebaceous glands. Those of the face are most frequently the subject of it. The secretion of the gland when first poured out is liquid, but that which lies near the surface suffers inspissation, and may be mixed with epithelial scales to such an extent that the mouth of the gland becomes plugged. This occluding plug, by exposure, dries and assumes a black appearance, so that the summit of the little nodule which the distended gland constructs is black-tipped. To the body so formed the name of **comedone** is applied. The secretion pent up within the gland becomes mixed more and more with epidermic cells and suffers inspissation, so that, when the comedone is squeezed, a worm-like white cast is expressed. It is said that the mite-like parasite, the **demodex folliculorum**, is often resident within this, but probably not so frequently as is supposed.

Sometimes the accumulated sebum lies beneath the epidermis and occasions a little tumour free from inflammation, to which the name of **milium** is applied. It is commonest upon the eyelids, temples, and labia minora.

The gland so obstructed frequently becomes inflamed, most likely from the influence of the contained secretion. The inflammation extends to the immediate vicinity of the gland, and to the root-sheath of a delicate hair into which the neck of the duct opens. It is now that the disease goes by the name of **acne.**

Suppuration follows, so that the little elevation becomes yellow-tipped, and pus mixed with sebaceous secretion may be squeezed out of it. The removal of the pus relieves the surrounding inflammation.

Boils or **furunculi** are of essentially the same nature, only the accompanying inflammation is much more severe. They arise usually around a hair follicle and its attached sebaceous gland; sometimes, it is said, around a sweat gland. The inflammation having run an acute course, suppuration sets in. The pus is evacuated naturally or artificially, and following upon this the central core of the furunculus sloughs out and the part rapidly heals. A cicatrix is left more or less well marked. The pus contains the organisms of suppuration.

A carbuncle is a still further development of the same process, but here the inflammation involves the subcutaneous tissue to a much greater extent. Indeed it is said (Warren) that the foci of inflammation are primarily located in the subcutaneous areolar tissue and press up towards the surface later on. There is this further difference also as compared with the furuncle, namely, that the foci of suppuration are multiple. The carbuncle is, in fact, a multilocular abscess, while the furunculus is unilocular.

Carbuncles may have a diameter of from 2 to 3 inches or more, and are accompanied by much fever and constitutional disturbance. A huge slough of the affected part takes place, and septic poisoning may follow. The depressing effects are long in being recovered from.

Acne rosacea or **gutta rosea** is in a manner a combination of an erythema or an eczema and acne. The classical seat is the nose and adjacent skin. It commences as an erythema-like redness of the part, followed by the appearance of acne nodules upon the reddened surface, and general tuberose thickening of the skin.

The disease is often associated with the alcoholic habit, but in many cases has no connection with it.

LICHEN (λειχήν, *lichen*).

1072. By *lichen* is understood a papular disease which throughout its whole life history suffers no further transformation into efflorescences of a higher grade, that is to say, which does not become vesicular or pustular (see p. 869), but suffers involution after it has reached the papular stage (Hebra and Kaposi).

It was a term in frequent use in Willan's classification to indicate a number of different skin diseases of a papular nature. Many of these, however, are not truly papular throughout, and as applied to them the term has now become obsolete. The chief varieties at present recognised are L. ruber, L. scrofulosus, and L. pilaris. Several other lichen-like diseases are described, such as L. circumscriptus, a serpiginous papular eruption occurring upon the skin of the chest and interscapular or lumbar regions, and L. marginatus, commencing as minute red points in patches, somewhat scaly on the surface and of a circular shape. The circle may be incomplete, so that the patch presents a horse-shoe character, and occasionally the circles meet and run together. The spreading in circles and the furfuraceous desquamation are the two distinctive points whereby it may be recognised.

Lichen ruber.—There are two recognised varieties of this, the one where the papules are pointed (L. ruber acuminatus), and the other where they are flat (L. ruber planus).

In the former the papules are about the size of a pin's head or millet seed, hard, red, and conical, and their summit is covered with a scale of epidermis. The eruption may cover the entire body or be limited to certain regions.

In the latter the papules are flat and of a wax-like glossy lustre.

The hair follicles and the papillary layers seem to be the chief seat of the anatomical lesions. These consist in a proliferation of the outer root-sheath towards the deepest part of the hair, together with cellular infiltration of the papillæ, and proliferation of the rete Malpighii covering them. In the flat variety many of the papillæ seem to have suffered atrophy. The epidermis is forced up by the cellular accumulation which underlies the rete mucosum, but the horny layer is only slightly thickened, except in the centre of a papule, where it forms a sort of conical plug fitting into a depression of the rete. Its apex corresponds with the orifice of a sweat duct (Crocker, No. 617, p. 218).

Lichen scrofulosus.—The papules in this form are inflammatory and of a red colour. There is an unusually great tendency to scaliness, and the disease is met with mostly in scrofulous subjects.

Lichen pilaris.—In this there is a spine-like elongation of each papilla, imparting to the hand a peculiar roughness when passed over the surface. This spine-like body consists of a hair follicle from which projects, it may be, an abortive hair whose base is surrounded by accumulated epidermis. The spine-like aspect is due to epidermic accretion.

It may just further be added that nothing is known of the cause of lichen in any of its forms.

PRURIGO (*prurire*, to itch).

1073. This is a disease characterised by crops of isolated chronically-inflamed papules. They are slightly raised, and more abundant on the extensor surfaces of the limbs than elsewhere. There is no recognised pathology of the disease. The papules, when examined microscopically, are seen to be simply papillæ infiltrated with liquid and a few inflammatory cells. In older-standing cases there is said to be a fibrous thickening of the corium itself. The hair follicles may be distended with accumulated epidermis, and the sweat ducts filled with epithelium. In more chronic cases, however, these structures are surrounded and compressed by the sclerosed derma.

MOLLUSCUM (*molluscum*, a mollusc, from *mollis*, soft).

1074. By ordinary **molluscum** is meant a fibrous tumour arising in the corium or in the subcutaneous areolar tissue, and pushing the true skin before it. It is a multiple tumour, and occurs by preference upon the flanks, shoulders, neck, and labia majora. Sometimes it occupies almost the entire cutaneous surface. In structure it is composed of loose areolar fibrous tissue, disposed in wavy bundles with wide spaces between, filled during life with lymphy liquid and fibroblasts. It sometimes undergoes retrograde metamorphosis, whereby its substance shrinks and vanishes, leaving a loose sac of skin behind. Those which are œdematous lose a great part of their bulk when excised, owing to the liquid draining off. The disease is one prevalent in tropical or subtropical climates. It is a comparatively rare disease in Europe.

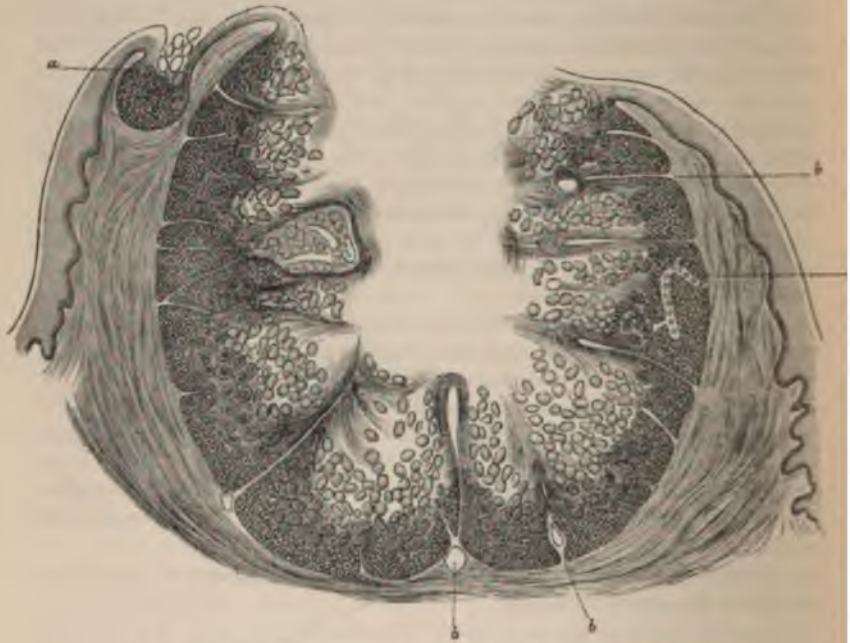


FIG. 534.—VERTICAL SECTION OF MOLLUSCUM NODULE (Oc. 3, Syst. 4 H.)

(*a*) Daughter nodule; (*b*, *b*, *b*) sections of blood-vessels; (*c*) epithelium with homogeneous molluscum bodies towards centre of the tumour.

This **molluscum fibrosum** must not be mistaken for **molluscum**

contagiosum, as the two diseases are seemingly unconnected, although the generic name is still retained for them both.

M. contagiosum appears to be a disease of the sebaceous glands, characterised by their becoming filled with epithelium and secretion, and so converted into tumour-like masses about the size of a lentil or larger. They occur in great numbers, and chiefly upon the skin of the face and trunk. Their surface has a peculiarly pearl-like transparent aspect; the centre of the nodule is depressed; and very often there is a minute opening in the centre communicating with the interior of the gland. From this opening a milky fluid or firmer wax-like substance can be squeezed out.

On microscopic examination the structure of the tumour is characteristic (Fig. 534). It has a somewhat adenomatous appearance, being subdivided into lobules and loculi by fibrous septa. The loculi are lined by cubical or cylindrical epithelium and the cavity of each is filled with loose epithelium, oil globules, and fat crystals, amidst which are the peculiar structures known as **molluscum bodies,** upon whose presence the reputed contagiosity of molluscum is founded. They consist (Figs. 534 and 535) of what look like large oval-shaped, degenerated epithelial cells, the protoplasm of which has assumed a hyaline or keratode-like aspect. Around them is a mantle or loose investment evidently more fibrous in structure than the rest of the body. They have been supposed to be parasitical in their nature, fashioned like gregarinidæ, and allied to psorosperms. Nothing has ever been conclusively demonstrated experimentally to show that they constitute the elements of contagion. Indeed that the disease has contagious properties is denied by many, although there are alleged instances where, for instance, a suckling child has apparently been infected by the face of the mother, and where the child again has infected the breast.

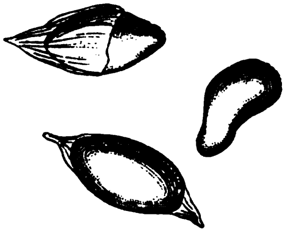


FIG. 535.—MOLLUSCUM BODIES.

It is generally supposed, as above described, that the disease takes origin within a sebaceous gland, yet it should be mentioned that Virchow, Bœck, Lukomsky, Thin, Crocker, and others trace it to the rete Malpighii and primarily to a hair follicle.

SCLERODERMA (σκληρός, *hard*, and δέρμα, *the skin*).

1075. By this is understood a state of the skin in which it becomes indurated or leather-like and rigid. There are two main forms of the disease, namely, the diffuse symmetrical form and the circumscribed unsymmetrical form or **morphœa.**

The former of these is a rare disease, and occurs chiefly upon the chest. The skin feels hard and cannot be readily pinched up, owing to its rigidity. It is not as a rule pigmented, nor are there any pink and white patches (Jamieson).

In the latter the skin presents an old-ivory-like colour, and is thickened as before. It occurs in oval-shaped patches, often in the course of a nerve. The blanched patch of skin may be surrounded by a violaceous or lilac areola.

According to Crocker (No. 617, p. 315), the changes in the diffuse form are almost confined to the corium and subjacent tissues. The blood-vessels are surrounded by a dense sheath of cells whose origin is unknown. These changes are preliminary to what is the essential lesion of the skin, namely, an increase in the connective tissue of the corium.

In the circumscribed form, the papillæ are less prominent than usual. The other features are essentially alike with the foregoing; the sclerous tissue surrounds the sebaceous and sweat ducts more particularly. Thrombi are also found in the vessels.

KELOID (κηλίς, *a stain or spot; εἶδος, likeness*).

1076. This may also be reckoned as one of the sclerous conditions of the skin. There are two varieties—(1) one in which the keloid patch occurs spontaneously, and (2) one in which it establishes itself in the centre of a cicatrix and spreads out therefrom.

The spontaneous variety arises without any apparent cause, and is located usually on the skin of the breast. It is said that the pressure of the corsets in women, or similar friction in men, such as that of leaning against a desk, is the determining cause of its appearing in this situation. Tuberous or discoidal growths show themselves in the corium beneath the papillary layer, which on microscopic examination appear to be composed simply of coarse fibrous tissue or of young cicatrix elements according to the age of the growth. The whole appearance of the patch is that of a somewhat elevated cicatrix.

The cicatricial variety takes origin in the cicatrices from wounds, those of syphilis, etc., and arising in the centre, spreads rapidly outwards, so as eventually to surpass the original cicatrix in dimensions. A cicatrix so small as a leech-bite may serve as the nucleus from which it grows.

The formation of cicatrix commences around the blood-vessels, and, in the idiopathic variety, leaves the papillæ still visible; in the cicatricial form these vanish.

ELEPHANTIASIS (*Pachydermia, Fuchs*).

1077. Many different overgrowths of skin and subcutaneous areolar tissue often go by the name of Elephantiasis. The name, properly speaking, however, should be limited to the affection of the leg in which the parts become so thickened that the foot is almost hidden, and hence comes to resemble the limb of an elephant.

True elephantiasis is sometimes known as E. Arabum, from having been originally described by the Arabian writers. E. Græcorum seems to have been a disease allied to, if not identical with, leprosy. It was at least an endemic and constitutional disease, characterised by the presence of tuberose infiltrations of the skin subject to ulceration.

The term at the present day refers to an hypertrophic condition of the skin, but more particularly of the subcutaneous, areolar, and other fibrous tissues, enlargement of the neighbouring lymphatics, and in the endemic varieties, by the presence of the blood parasite, the **filaria sanguinis hominis,** in the blood and elephantoid tissues.

It occurs endemically both in tropical and subtropical climates, and sporadically in this and other European countries.

Elephantiasis of the Leg.—The commencement of the disease in this region is characterised by an attack of an erythematous or erysipelatous nature, which after passing off leaves a certain amount of œdematous swelling. This first attack is succeeded by others, which also pass off but leave an increasing degree of swelling, which now is accompanied by fibrous induration. The fibrous excess induces great thickening of the parts, which becomes permanent. During the time of the inflammatory exacerbations the individual suffers from high fever, and other signs of a general disturbance of the functions of the body.

The skin of the leg from the knee downwards becomes stretched, tense, and it may be smooth, but sometimes it presents tuberose projections, or huge welts of skin may overlap the foot and partly conceal it.

An eczematous efflorescence also shows on the altered parts, from which a copious watery discharge is given off. Sometimes it happens that a crack or fissure forms on the surface from which lymph is given off in abundance—a veritable lymph-fistula. The part may pit on pressure, but as a rule is much harder than one which is merely œdematous. Cut into, there is seen to be great thickening of the areolar tissue, extending down to the fibrous septa between the muscles. The muscles themselves are more or less atrophied, probably from the pressure of the surrounding fibrous parts. The bones of the limb are also altered. They are sclerous in parts, necrosed in others, and from them excrescences like those following periosteitis may be found projecting into neighbouring tissues. The corium, although altered, is not so much thickened as subjacent parts. The hair follicles and glands are widely separated, and lie apparently more deeply embedded than normally. The veins are abundant, some of them large, others reduced in size. They are filled with thrombi, and are in process of fibrous obliteration (Hebra, No. 616, iii. p. 142). The lymphatics leading up to the papillæ from the subcutaneous fat tissue are swollen and readily recognisable on microscopic examination. Large cyst-like cavities are seen here and there, presumably distended lymph-vessels; and within the areolæ of the new-formed fibrous basis of the overgrowth is a new formation of gelatinous and apparently myxomatous tissue in which are myxoma-like cells. Some authors say the fat is increased in subcutaneous parts. This, however, is questionable; the new formation seems to be more purely fibrous. The popliteal and inguinal lymph-glands are enlarged, and the lymph-vessels in the groin can be felt as knotted cord-like structures beneath the skin.

Elephantiasis of the Genitals.—The scrotum, penis, labia, and clitoris are all subject to growths which are generally held to be of a nature alike with that just described. Truly enormous tumours may grow from any of these sites. That of the scrotum, known as *nævoid elephantiasis* or *lymph-scrotum*, grows to such a size that it interferes seriously with locomotion. It entirely envelops the penis, whose skin becomes inverted and transformed into a spurious mucous membrane, while a rut-like channel in the tumour conveys the urine away from this.

The skin of the scrotum, although thickened, is not the part where the increase in bulk has chiefly taken place. It is the areolar tissue below which is chiefly to blame. This is peculiarly opened out, and its spaces are loaded with fluid which runs out copiously when the part is incised. Lymph indeed may escape from the surface during life, so that a condition of **lymphorrhœa** may be set up. The skin is often brown pigmented. Sloughs may form on the surface.

The disease, unlike that of the leg, is not initiated and accompanied by successive attacks of erysipelas. It begins, on the contrary, in a circumscribed hard mass within the scrotal tissues, which subsequently spreads and invades adjacent parts.

Elephantiasis telangeiectodes or **lymphangeiectodes.**—This is a congenital elephantine disease, apparently due in part to distension of the lymphatic vessels, and usually affecting one limb. It is well developed at the time of birth, but the swelling may increase subsequently.

Elephantiasis nasi.—A tuberose elephantoid enlargement of the tip of the nose is sometimes met with. The tumour resulting therefrom may come up to a hen's egg in bulk and produce a hideous deformity. The skin is peculiarly rough and nodulated, and enlarged sebaceous glands may sometimes be seen projecting from it. Curiously, few descriptions of this deformity exist in our text-books of cutaneous diseases or of pathology. In surgical works it is usually called "a lipoma." This, however, is a misnomer, seeing that the new growth is unusually poor in fat tissue, and that the tumour is certainly not due to an accumulation of this.

The tuberous mass is composed of dense fibrous tissue with comparatively few blood-vessels in it, and is quite devoid of anything like the structure of a lipoma. Sections of sebaceous glands distended with thickened secretion are seen lying near the surface. The appearance presented by the tumour mass in all respects corresponds to that of an elephantiasis of old standing in other parts of the body.

RHINOSCLEROMA.

1078. Rhinoscleroma is characterised by massive thickening, and induration of the mucous membrane of the nares, nasal septum, and it may be of the lips. In some instances the thickening may extend to the mucosa of the pharynx and larynx. The tumefaction commences in the nose in the form of hard red or grayish-pink nodular masses which are painful on pressure. The neighbouring parts are swollen and the nose is tumefied. The glottis may become stenosed. The disease spreads slowly, a patch of from 4 to 5 centimètres' breadth continuing to grow for a matter of fifteen to twenty years. In its clinical features it has a certain resemblance to lupus. In this country the disease is very rare, but it is commoner in Italy and Austria, and occurs sporadically in some parts of Germany.

The malady is caused apparently by a short thick bacillus, rarely longer than 3 μ, and usually two to three times as long as broad. It may, however, attain to 7 μ in length. It has been described by Chiari and others, and more especially by Cornil and Alvarez (No. 4, vi. 1885, p. 11; *also*, Alvarez, *ibid.* viii. 1886, pp. 196 and 207). According to Alvarez the rods are difficult to stain, and can be coloured best by a strong methyl-violet B or violet 6B solution. They are left in it for twenty-four hours. The solution may be made with or without aniline water. The rods are enclosed in a capsule, sometimes several in one capsule, as in the case of Friedländer's pneumo-bacillus. Their ends are rounded, and they are often associated in pairs. Within the fibrous meshes of the tumour there are numerous large hyaline cells, and the bacilli above described are often seen lying in their substance. At other times, however, they lie quite free in the interstices of the tissue or in the lymph-vessels. When stained as above described, three or more coloured grains may be seen in their interior.

The *surface growth* on gelatine has the same nail-like character as Friedländer's capsule bacillus. The organism is aërobic, non-motile, and does not liquefy the gelatine. On potato the line of inoculation is marked by a cream-yellow streak in which gas bubbles may have developed. When stained with a basic aniline dye the rod of rhinoscleroma is not decolorised by Gram's method, while Friedländer's bacillus is. In other respects, however, it resembles Friedländer's organism so much that some bacteriologists are not satisfied of its being a distinct species.

LUPUS (see vol. i. p. 437).

LEPROSY (λεπρός, *scaly*).

Syn.—Lepra, Elephantiasis Græcorum, or Leontiasis.

1079. **Varieties.**—Three forms of the disease are generally recognised, namely—

(1) The tuberculated (L. nodosa).
(2) The anæsthetic (L. nervosa).
(3) The mixed.

Although there is a tendency for the first and second of these to coalesce, yet many cases run their entire course restricted to the one or the other type.

Distribution.—At the present day the only part of Europe where it is common is Norway, but sporadic cases occur from time to time even in this country. In Scotland it seems to have been a common disease centuries ago. The village of Liberton, near Edinburgh, is supposed to take its name from the leper-house which stood in this locality. It occurs in Iceland, the Russian coast of the Baltic and Gulf of Finland, in Portugal, Spain, Italy, Turkey, Greece, Palestine, and many of the Mediterranean islands. It is met with almost all round the coast of Africa, in Arabia, Persia, China, Japan, and British Guiana. It is rare in the United States and in Australia. It is said to prevail in districts where fish, and more particularly putrid fish, forms a staple article of diet.

The Tuberculated Form.—The disease manifests itself outwardly as an erythematous patch, having at first, it may be, a mere blush of redness, but assuming more of a red or bluish colour later on. The patch soon becomes infiltrated, and the infiltration is accompanied by tenderness or absolute pain of a burning character. The infiltration goes on increasing while the colour may fade, and, coincident with their fading, the infiltrated patches become tuberculated —that is to say, nodules form on their surfaces. These vary in size from a millet seed to a pea or hen's egg, and they may appear in successive crops.

The primary seat of the eruption is usually the head and face, and most frequently it shows first on the cheeks, temples, or forehead. The swelling of these parts gives rise to a lion-like cast of features. Sometimes the locality first invaded is that of the anterior aspect of the forearms or the thighs. The tuberculated masses grow larger, while the skin becomes dry and cracks. The nails fall off, the hair may be shed. Ulceration ensues later on, leaving an intractable wound.

The progress of the disease is very slow, and it reaches its climax in from eight to nine years. The affected individual dies exhausted or from some complication such as tubercular (lepric ?) disease of the lungs.

The state of the **internal organs** varies. The liver may be enlarged, and, if infected with the lepra bacillus, will very likely be found in a state of diffuse interstitial cirrhosis. The spleen is also enlarged, and it is said (Delépine) to be likewise cirrhotic. The lymphatic ganglia of particular regions, such as the bend of the elbow, are swollen. The state of the lungs is of great importance from an etiological point of view. The notion entertained of the disease of late years is that it is a variety of tuberculosis. And certainly the state of the lungs would tend to favour that theory of the disease. The percentage of deaths from what is called pulmonary phthisis in the disease is registered variously at from 11 to 37 per cent. There does not seem to be much difference in the appearance of the lung as compared with that of ordinary tubercular pneumonia. According to Delépine (No. 192, xlii. 1891, p. 386) the lesions are essentially those of cheesy broncho-pneumonia, combined with interstitial thickening, but without the occurrence of miliary tubercles.

The Anæsthetic Form.—This is characterised by the lepra infiltration running along the nerve trunks. Patches resembling those of the initiatory stage in the tuberculated variety show themselves most often on the back, shoulders, arms, thighs, around the knees, and on the face. They are not anæsthetic at first; their appearance, in fact, may be accompanied by a sensation of pricking pain. The diseased condition of the skin often follows the course of a nerve, the musculo-spiral more frequently than any other (Hillis).

Evidence of the nerves leading to the part being early implicated is to hand in the fact that the individual begins to lose tactile sensibility. It is said that the nerves are the primary seat of the disease.

The patches on the skin next begin to assume a serpiginous character, and so anæsthetic does the part become that it is often burnt accidentally. Ulceration sets in; it commences frequently on the sole of the foot (Hillis), apparently from a small wound or a burn. The muscles atrophy, and probably by the end of seven or eight years several of the fingers, or it may be an entire hand or foot, has sloughed off. The bones die and are ejected.

The nerves leading to the affected parts are swollen not uniformly but at intervals. The swelling is caused by a leprous infiltration of the fibrous septa of the nerve. The lesion seems to be a chronic interstitial neuritis, and indeed this interstitial character of the new formation appears to be one which is common to most of the affected organs. Even in tuberculated leprosy swellings due to the above cause will be found on the nerves of the extremities.

The Mixed Form.—The signs and symptoms of the two varieties are present in the same subject. The tuberculated characters of the disease are always prominent, and hence it has been named by Hillis (No. 637, p. 125) "Mixed tuberculated."

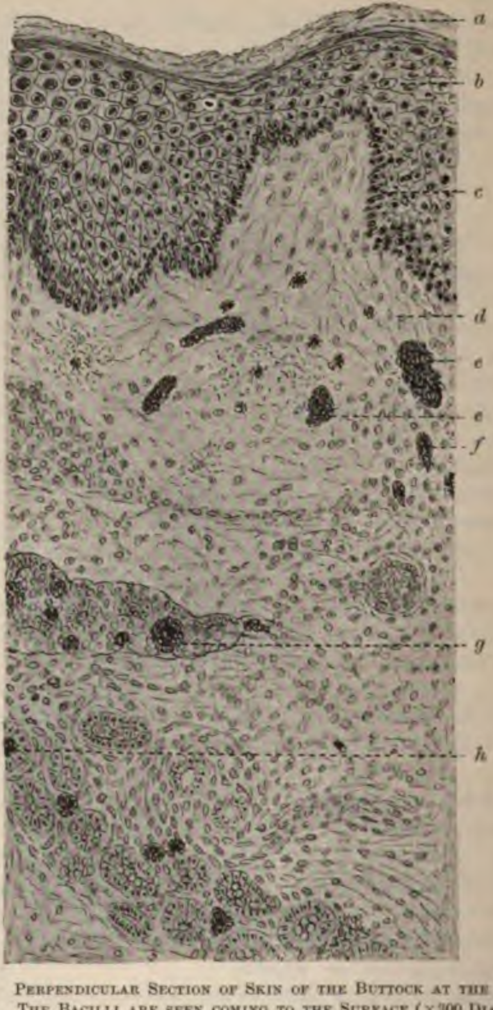


FIG. 536.—LEPRA. PERPENDICULAR SECTION OF SKIN OF THE BUTTOCK AT THE MARGIN OF AN ULCER. THE BACILLI ARE SEEN COMING TO THE SURFACE (×300 DIAMS.)

From a preparation kindly lent to the author by Professor Delépine.

(*a*) Horny layer of epidermis; (*b*) deeper layers of same; (*c*) rete Malpighii; (*d*) papillary layer of cutis vera; (*e*, *e*) masses of bacillus lying in the papillary layer; (*f*) same enclosed in large (lepra) cells; (*g*) bacillus occupying a sweat-gland; (*h*) same in a sweat-gland duct (Ziehl-Neelsen stain).

The Lepra Bacillus.—This was discovered as early as the year 1874, by Hansen (No. 638, Heft ix.), in the large cells of the tumour masses. Even at that early date he considered it to be the cause of the disease. Later on, it was more fully described by him (see Bibliog.). Both Hansen and Neisser (No. 13, lxxxiv. 1881, p. 514) afterwards drew attention to the occurrence of this bacillus in the new formations of the skin, mucosa of the mouth, palate and larynx, interstitial tissue of peripheral nerves, the cornea, in cartilage, in the testicle, lymph-glands, spleen, liver, etc. They both failed to find it in freshly-drawn blood, but Köbner (No. 13, lxxxviii. 1882, p. 302) was successful in doing so.

Since then the examination of the affected parts by various observers (see Bibliog.) has fully established the fact that a specific bacillus is widely disseminated throughout the whole body, even in parts like bone marrow (Delépine, No. 192, xlii. 1890-91, p. 386), in which, beyond a little inflammatory redness, no macroscopic change is perceptible. Huge thrombus-like masses of this bacillus are to be seen blocking the channels of the blood-vessels of some parts. They are abundant in the portal branches of the liver.

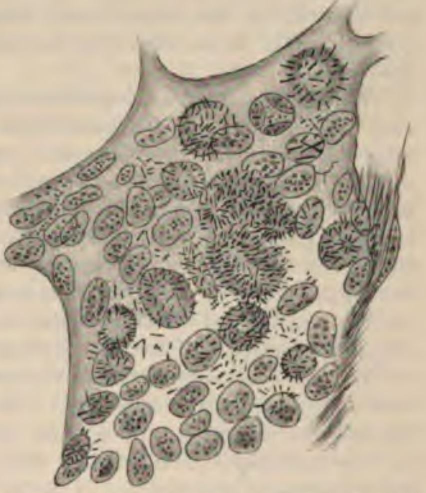


FIG. 537.—LEPRA. NODULE IN FAT TISSUE AT SOME DISTANCE FROM A TRANSPLANTATION OF LEPRA TISSUE ON TO THE SKIN OF THE CAT.

It shows the part beset with the lepra bacillus, a large proportion of the bacilli being contained in the so-called lepra cells (Ehrlich double stain. Zeiss B. B. 3).

The bacillus, however, induces a form of chronic inflammation of most tissues in which it has taken up its residence, followed by small-cell infiltration and fibrous overgrowth, and it is these two elements which constitute the basis of the lepra deposits. Within the infiltrated parts *large vacuolated cells*, from the size of a pus corpuscle to five times this size, and with several vesicular nuclei, are to be seen. They were described long ago by Virchow (No. 35, ii.). The bacilli, as pointed out by Neisser (No. 13, lxxxiv. 1881, p. 517), fill their protoplasm indiscriminately, or what is commoner, are gathered together within it in little groups, in which the individual bacilli are placed parallel to each other. Among the bacilli shorter bodies are always seen, together with granular particles. *Giant cells* with many nuclei in their interior are found here and there. They resemble those of tubercle, but are not so numerous. They may be filled with the bacilli, and where they are aggregated the part tends to caseate and ulcerate.

Specific Characters.—According to Hansen the bacilli are from

5 μ to 6 μ long by 1 μ broad, but measurements by various authors are not all alike, showing that there is considerable fluctuation in their proportions. They resemble tubercle bacilli so closely that by many they have been regarded as identical. They stain as tubercle bacilli stain, but are less curved and are more pointed at the ends. When stained with a basic aniline dye they are not decolorised by Gram's method. They are not only contained in the large cells above referred to, but are often found lying free. Those which are contained in cells are less easily decolorised than those which are not. They are generally held to be immobile, but there is a conflict of opinion on the subject.

Within the infiltrated patches of skin the bacilli (Fig. 536) are very numerous. They are contained in the same large cells as in other parts, and seem to spread from the deep parts of the derma towards the surface. The spherical masses formed by these infiltrated large cells look very like the giant-cells infiltrated with tubercle bacilli found in pulmonary tuberculosis of the horse (Fig. 287). While these fixed cells take up the bacillus plenteously, it appears to be equally true that cells with nomadic tendencies fail to do so.

The lymphatics of the skin are full of the bacillus, so much so that the so-called "lepra-cells" have been alleged to be cross-sections of these.

The liquid squeezed out from the nodules is also largely contaminated with the characteristic organism. The walls of the *blood-vessels* within the nodules are seldom free from it. Small deposits are contained in the muscularis and intima, and from this source the bacillus gains access to the blood. It is to be presumed that it multiplies within the body chiefly by fission, but Neisser asserts that it also increases by sporing.

The cultivation of the bacillus, unlike that of tubercle, has till now proved a matter of the greatest difficulty. In fact it may be questioned whether its cultivation *in vitro* has ever yet been accomplished. Rake, for instance (No. 43, xxviii. 1891, p. 25), after years of diligent endeavour, utterly failed to grow it artificially. Burdoni-Uffreduzzi (No. 366, iii. 1887, p. 178) supposed that he had isolated it from bone marrow.

Contagiosity.—The disease is undoubtedly contagious. The case of Father Damien, who died from the disease while attending upon the sick in the Molucca Islands, and the transfer experiment made by Arning upon the condemned criminal Klann, where the disease manifested itself three years after inoculation had been performed, have put the question of its contagiosity beyond doubt. On account of the long period of incubation the source from which the disease has been derived is often forgotten.

Inoculation experiments made by Rake (No. 43, xxviii. 1891, p. 26) on individuals already suffering from lepra (L. anæsthetica) have proved singularly unsuccessful. Of thirty-four cases of lepra anæsthetica inoculated with lepra-lymph or pieces of fresh lepra tissues, not a single inoculation took. A nodule occasionally formed in the part but gradually disappeared.

The transference of the disease by inoculation to the lower animals has proved singularly unsuccessful. Injections of blood, tissue-lymph from lepra tumours, and deposits from leprous urine, as well as the transplantation of fragments of lepra tissue, at the hands of various experimenters, have failed to convey the disease to any of the various animals upon which the experiment has been practised, even although the bacilli may remain embedded in the part and still capable of being stained from four to seven months after their introduction. Indeed Damsch (No. 13, xcii. 1883, p. 20) believes that they actually multiply—a stage the nearest to inoculation which has been obtained.

Question of Identity of Tuberculosis and Leprosy.—This is a matter of the greatest interest and one which is still under debate. The points of similarity between the two diseases are certainly many. Thus the bacillus of lepra resembles that of tuberculosis both morphologically and in respect of its staining properties. There may be minor points of difference, but these are so slight as to be overbalanced by those of resemblance. Then the lesions produced by the organism have a certain similarity. In both, the tissues react as in a chronic inflammation, with production of much cicatricial substance, giant-cells, etc. And, lastly, there is the fact that a large proportion of lepers die from what seems to be ordinary tubercular pneumonia, or some other manifestation of tubercle in the lung. We see the tubercle bacillus grow in different parts of the body under such varying auspices and with so varied a life-history that it would not be at all astonishing if this disease also turns out to be simply one of its manifestations.

Treatment with tuberculin has been practised by Goldschmidt (No. 43, xxviii. 1891, p. 368) and others, but, so far as the conferring of any beneficial result is concerned, without positive result. In many of the cases under observation the individual became so weak that further treatment by injection of tuberculin had to be suspended. In one of Goldschmidt's cases the injection induced inflammatory reaction in the lepra nodules, with some amount of retrogression of the tissue infiltration, but with no permanent benefit as regards the eradication of the disease.

Literature on Leprosy.—**Babes**: Arch. de physiol. norm. et path., 1883, p. 42. **Boinet and Borrel** (Giant-cells): Compt. rend. Soc. de biol., ii. 1890, p. 38. **Cantlie**: Leprosy in Hong-Kong, 1890. **Damsch** (Transference to Animals): Arch. f. path. Anat., xcii. 1883, p. 20. **Delépine**: Seventh International Congress for Hygiene, 1892, vol. ii. Bacteriology. **Delépine and Slater**: Trans. Path. Soc. Lond., xlii. 1890-91, p. 386. **Favrat**: Centralbl. f. Bakteriol. u. Parasitenkrank., x. 1891, p. 119. **Goldschmidt** (Action of Tuberculin upon): Berl. klin. Wochnschr., xxviii. 1891, pp. 28, 368. **Hansen**: Arch. f. path. Anat., lxxix. 1880, p. 32; *Ibid.*, xc. 1882, p. 542; *Ibid.*, cxx. 1890, p. 476; *also*, Edin. Med. Journ., xxxvi. 1890-91, p. 126. **Heidenstam**: Practitioner, xliv. 1890, p. 386. **Kanthack and Barclay** (Cultivation of Bacillus): Arch. f. path. Anat., cxxv. 1891, p. 398; *also*, Brit. Med. Journ., 1891, i. p. 1330. **Köbner**: Arch. f. path. Anat., lxxxviii. 1882, p. 282. **Leloir**: Traité pratique et théorique de la lèpre, 1886. **Neisser**: Arch. f. path.

Anat., lxxxiv. 1881, p. 514; *also*, Fortschr. d. Med., vii. 1889, p. 816; *also*, Verhandl. d. deut. dermat. Gesellsch., Wien, 1889, i. p. 29. **Philippson** (Symbiosis of L. and Tubercle): Arch. f. path. Anat., cxxxii. 1893, p. 529; *also* (Histology), Arch. f. path. Anat., cxxxii. 1893, p. 229. **Rake**: Lancet, 1890, i. p. 569; *also*, Berl. klin. Wochnschr., xxviii. 1891, p. 25. **Unna**: Deut. med. Wochnschr., No. 32, 1885-86; *also*, Dub. Journ. Med. Sc., lxxxix. 1890, p. 112; *also* (New Double Stain for L. and Tubercle Bacilli), Monatsch. f. prakt. Dermatol., xvi. 1893, p. 399. **Vossins**: Beitr. z. path. Anat. u. z. allg. Path., viii. 1890, p. 352. **Wynne**: Lancet, 1890, i. p. 14.

DISEASES OF THE SKIN DUE TO PARASITIC MOULDS.

1080. The skin diseases resulting from the presence and ingrowth of vegetable parasites are known by the generic name *Dermatomycoses*. Most of these vegetable parasites belong to the moulds, and of these there are at least three which are distinctly recognised, namely, Achorion Schönleinii, the parasite of favus; Trichophyton tonsurans, or that of ringworm; and Microsporon furfur, or that of tinea versicolor. They all live in the epidermis. Some of them extend down the hair sheath, some of them into the derma itself. None of them, however, seem to thrive well on tissues which are not epidermic. They are all capable of communicating the disease by contagion. It has been asserted (Fox) that the atmosphere may act as the medium of conveyance. The trichophyton tonsurans is, of the whole of them, that which is most easily communicable; its contagiosity is very great. Although persistent in some cases and troublesome as local affections, they do not impair the general health to such an extent as to endanger life. So far as known, they do not spread to internal parts.

Favus.

Syn.—Tinea favosa, Honeycomb ringworm.

The disease manifests itself on various parts of the body, mostly where hair is abundant. Regions in which hair is sparse or absent, such as the roots of the nails, are, however, not exempt from it. That affecting the nails is known as **Onychomycosis favosa.** The part oftenest affected is the scalp, but patches alike with those of the scalp may be located on the trunk or limbs. It affects young subjects almost exclusively.

Cup-shaped crusts or scutula of a canary-yellow colour form on the surface. Each crust is perforated by a hair, and its margin is considerably raised above the adjacent parts. The crusts are placed in such close contiguity that they give the incrustation a honeycomb-like appearance.

Examined microscopically, the scutula are found to be composed of dead epidermic cells, bound together by the mycelial filaments and spores of the Achorion. The Achorion was described by Schönlein in the year 1839. The spores are abundant and of oval shape; the mycelium is branched extensively, and is, relatively to the spores, more abundant towards the surface of the scutulum than deeper down. The hair shaft and bulb and the root sheath are filled with the parasite, hence one difficulty in eradicating it. The fungus penetrates perpendicularly into the skin; it passes through the epidermis into the derma, which it irritates.

Ringworm.

Syn.—Tinea tonsurans, Herpes tonsurans, Herpes circinatus, Tinea circinata.

The disease manifests itself somewhat differently, or at any rate shows certain peculiarities, according as it is situated on the scalp, the beard, or the trunk and extremities.

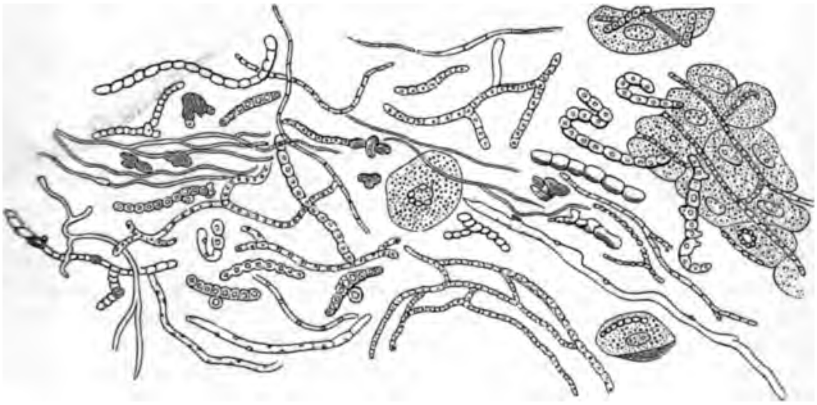


FIG. 538.—FUNGUS FROM FAVUS—THE ACHORION SCHÖNLEINII.

Fungus elements from lower part of favus crust. Threads and gonidia of different calibre and various form. To the right a collection of epidermic scales.

In the scalp the disease appears first in the form of circular slightly red patches covered with scales. The circular character of the patches is in course of time lost. The fungus penetrates deeply and becomes more diffuse. The eruption is finely papular to begin with; it does not usually become vesicular in the scalp. The growth of hair is scanty, and more or less baldness resembling a tonsure follows. The surface is covered with white, rough, dry, powdery scales. The parts underlying the scaly deposit are more or less red and congested.

In the case of the beard (Sycosis menti), reddish, dry, and slightly scaly papules form around the hairs. The hairs become withered and may crack off. The papules grow longer, become more infiltrated, and from them a sticky yellowish discharge may be thrown off. This dries into crusts, which, when removed, carry with them the frangible diseased hair.

On other parts of the body, and more especially where the hair has a fine lanugo character, papules or vesicles, arranged, it may be, in discs or circlets, constitute the typical outward manifestation of the presence of the parasite.

The Parasite.—The disease is supposed to be due, as aforesaid, to the trichophyton tonsurans, a parasite discovered by Malmsten in 1843. As in the case of the other mould parasites, mycelial threads and spores are the two forms which the organism assumes. The older writers accepted the unity of the organism in all situations. It was Gruby who first attributed the sycosis menti to the Trichophyton tonsurans.

Of late, however, doubt has been thrown on this alleged uniformity of the parasite, although it is acknowledged that in all cases the features of relationship are very close. Furthmann and Neebe, for instance (No. 622, xiii. 1891, p. 478), made out that there were in reality four species of parasite.

According to Sabouraud (No. 423, vii. 1893, p. 497), in the case of the beard and smooth skin, the spores are particularly large—larger than a blood corpuscle, and are contained in filaments (Fig. 539), whereas in the case of the hairy scalp of children this large-spore variety of the fungus is met with in only one-third of the cases. In the remaining two-thirds the parasite appears to be of a different species, characterised among other features by the spores being smaller (only 2-3 μ in diam.). The spores of the two varieties are never mixed in the same head. He calls the one parasite *Tinea microsporon*, the other *Tinea megalosporon*.

The microsporon induces a disease essentially of the hair, and one which occurs in childhood. It appears to be identical with the parasite of ordinary contagious herpes of the horse.

The megalosporon may take up its stronghold in the hairy scalp of the child, in the beard of the adult, or in the epidermis of the trunk and limbs. It calls forth deep-seated dermatitis and suppuration; it is pyogenic. The invasion by the parasite of the hair-follicle excites a folliculitis or perifolliculitis. The follicular lesions are capped by a sharply circumscribed crust or cake. The underlying derma is the subject of a deep-seated dermatitis. The lesion is always confounded at first with a small furuncle or carbuncle.

He believes that it has its natural habitat in the horse. The horse suffers from a pustular disease, chiefly of the face and nose, a disease almost identical with that in question of Man. Hence he considers that the name applicable to the parasite is Trichophyton megalosporon pyogenes equi. It prevails as a saprophyte, he believes, and the horse becomes infected from bedding, etc.

The chief diagnostic point is the great size of certain of the spores. They are most readily obtained for culture purposes from an incision into the skin, or from the discharge of the pustules.

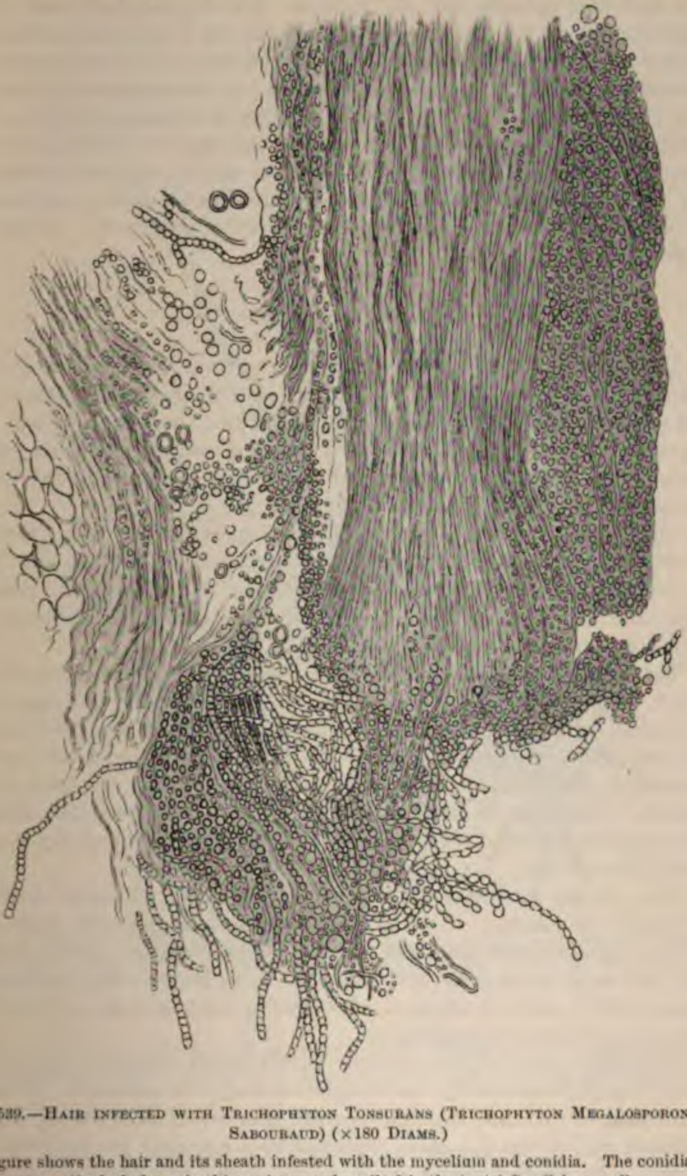


FIG. 539.—HAIR INFECTED WITH TRICHOPHYTON TONSURANS (TRICHOPHYTON MEGALOSPORON OF SABOURAUD) (×180 DIAMS.)

The figure shows the hair and its sheath infested with the mycelium and conidia. The conidia are particularly large in this variety, as described in the text (after Sabouraud).

It grows best on must of beer diluted to one-fifth or one-tenth, or even pure and gélosed, and on potato. The temperature best suited for its growth is 18° C. On gélosed beer-must a puncture inoculation grows in the form of a fine white downy tuft, which, increasing in dimensions, throws out rays. These give the colony a stellate appearance. By seven days the entire surface is covered with a white powder. On peptonised gélose the culture has no central tuft; it forms simply a plaque of white powder, whose rays are short and only slightly arborescent. A linear inoculation on potato spreads out into a tuft, and has the same white powdery appearance. It liquefies gelatine.

PITYRIASIS VERSICOLOR.

The parasite in this case is the Microsporon furfur, described by Eichstedt. It lives in the superficial layers of the epidermis, and does not, as a rule, penetrate deeply down into the hair sheaths. The eruption takes the form of brown patches, varying in size, and of irregular outline. The patches are not raised to any perceptible extent above the ordinary level of the skin.

The mycelium is branched, and the spores differ from those of the other two fungous diseases just described in the fact that they are collected in masses (Fig. 540). They are usually of rounded shape, and are somewhat larger than in the case of the trichophyton. They are also of remarkably uniform size.

The parasite can be cultivated artificially, the best method of procedure being the following:—The superjacent skin having been disinfected with alcohol and ether, the squames are detached on to 5 per cent glycerine-gélose. Side by side with colonies of bacteria colonies of the fungus are obtained. The experiment does not always succeed. The growth is often choked out by bacteria which fructify more rapidly than the true fungus. It can be conveyed by inoculation to the rabbit.

The mould grows readily upon 5 per cent glycerine-bouillon, either acid or alkaline, in 10 per cent peptonised gelatine, also either acid or alkaline, and on other media. The reaction of the medium does not seem to exercise any influence upon its growth. It develops equally well in acids or alkalies. Its development is rapid at 35°-36° C., slower at ordinary temperatures.

The appearance of the culture varies much with the medium on which it is grown. It can be recognised easily on gelatine. Sown on the surface of gelatine, the microsporon plunges at once deeply into its substance and forms a hollow, carpeted by a mycelial growth of yellow colour. The thallus raises itself more slowly out of this hollow in prominences of various form. The aspect of a puncture cultivation presents nothing peculiar or characteristic. The microsporon propagates by the aid of conidia.

ALOPECHIA OR BALDNESS.

1081. The falling out of the hair, ending in permanent baldness, is usually an accompaniment of increasing years. The cause of the hair not being renewed has never been explained. One peculiar form of baldness is known as **Alopechia areata.** It is said to be caused by the growth of a microphyte in the hair sheath (the micrococcus decalvans). The patches are peculiarly circumscribed, and the hair is either quite destroyed or is present in the shape of a fine lanugo. It may grow in again even when apparently it has been completely lost.

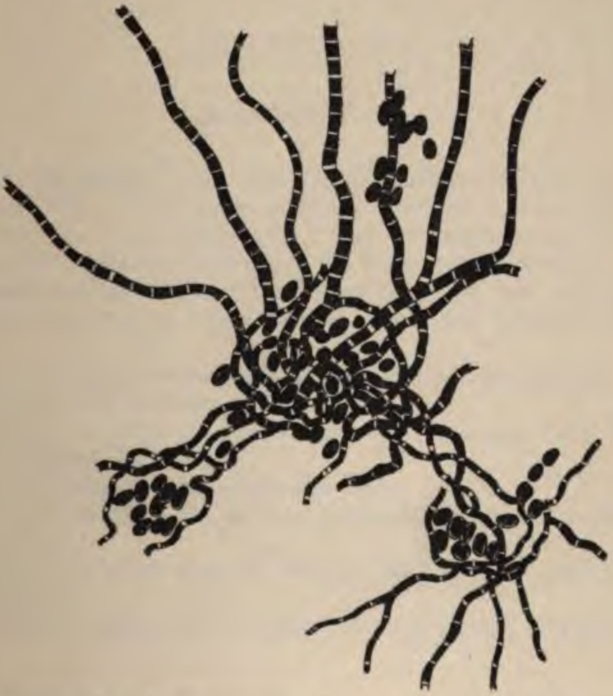


FIG. 540.—FUNGUS OF PITYRIASIS VERSICOLOR—MICROSPORON FURFUR SHOWING THE MYCELIUM TOGETHER WITH SPORES IN GROUPS ($\frac{1}{12}$ homog. Imm. Crouch, Hartk., Oc. 3. Stained with Methylene Blue).

GENERAL LITERATURE ON THE SKIN.

Anderson (M'C.): A Treatise on Diseases of the Skin, 1887. **Bateman**: A Practical Synopsis of Cutaneous Diseases according to the Arrangement of Dr. Willan, 1819. **Behrend**: Die Hautkrankheiten, 1883. **Bulkley**: Manual of Diseases of the Skin, 1882. **Burnett**: Diseases of Skin from Organismic Standpoint,

1886. **Calomiatti**: Trattato di anatomia patologica della pelle, 1884. **Crocker**: Diseases of the Skin, 1888. **Duhring**: A Practical Treatise on Diseases of the Skin, 1886. **Eichhoff**: Die Hautkrankheiten, 1890. **Fox (W. T.) and T. Colcott Fox**: Skin Diseases, 1883. **Jamieson**: Diseases of the Skin, 1892. **Kaposi**: Pathologie u. Therapie d. Hautkrankheiten, 1887. **Leloir and Vidal**: Traité descriptif des maladies de la peau, 1889-91. **Neumann**: Lehrbuch d. Hautkrankheiten, 1880; *also, Eng. Transl.* **Robinson**: A Manual of Dermatology, 1885. **Shoemaker**: A Practical Treatise on Diseases of the Skin, 1888. **Squire**: A Manual of Diseases of the Skin, 1887. **Unna**: Dermatologische Studien, 1886-90. **Willan**: On Cutaneous Diseases.

CHAPTER XCI

MALFORMATIONS

1082. **Definition.**—As such are understood *those departures from the normal form of the organism, or of single parts of it, which follow upon some disturbance in its development.* They are known as monstrosities, anomalies, or varieties, according to the amount of deviation.

Classification. — Many have been proposed, but probably the most comprehensive is that founded upon their etiology, namely, into—

(1) Those malformations due to intra-uterine inflammation.

(2) Those due to pressure; and

(3) Those in which there has been some inherent defect in the primitive cells of the embryo.

The last group may be subdivided into—

(*a*) Those in which there is an excess of development—Monstra per excessum.

(*b*) Those in which there is defective development—Monstra per defectum; and

(*c*) Those in which the individual is single, double, or triple.

(1) MONSTERS FROM INFLAMMATORY CAUSES.

1083. That inflammation may occur in the fœtus during intra-uterine life is undoubted. Exudation, suppuration, and formation of cicatrices may follow, and adhesions be formed. Thus the fœtus is sometimes born with evidence of inflammatory affection of the skin, adhesive or exudative peritonitis or pleurisy, endocarditis, interstitial hepatitis, pneumonia, etc. Similar lesions unquestionably inflammatory in their nature occur in the fœtal membranes.

The causes of such affections (Perls) are mainly—

(1) *Blows upon the Part.*—Such are more likely to take effect when the fœtus is surrounded by a small quantity of liquor amnii.

(2) *Certain Poisons transmitted from the Mother.*—The placenta seems to be a sufficient protection against most poisonous states of body existing in the mother, but not against all. Thus the fœtal blood only rarely contains the **anthrax bacillus** when the circulation of the mother is full of it. It is said also that the poison of **syphilis** is not transmitted through the placenta, but is contained in the spermatozoid or ovum. Maffucci's experiments on the inoculation of eggs with **tubercle** might lend some weight to this supposition. It has even been asserted (Jani) that tubercle bacilli are present in the seminal ducts and Fallopian tubes in tubercular persons without any evidence of local tubercular disease.

It seems, however, that **measles, smallpox,** and **scarlet fever** can be transferred directly from mother to child; and as the liquor amnii is a maternal transudate, it is supposed that the contagion takes place through it.

The inflammations excited by such poisons may manifest themselves in various ways, and as a result of them the tissues may become profoundly altered, closure of ducts may occur, or a more or less complete sphacelation of parts may follow upon adhesions which have been contracted. Where these adhesions come to press upon important parts, such as the head end of the embryo, development may be completely arrested.

(2) Monsters resulting from Pressure.

1084. Pressure, however, is often brought to bear upon the fœtus in other ways than by adhesions. Thus there may be too small a quantity of amniotic liquid, so that the fœtus cannot float freely in it; the navel-string may be tightly bound round a limb or round the neck of the fœtus, occasioning intra-uterine amputation or decapitation as the case may be. In the case of defective quantity of amniotic liquid the head end of the embryo is said to suffer most; and this from the fact that the head fold of the amnion comes in contact with it.

(3) Monsters due to some Inherent Defect in the Primitive Cells of the Embryo.

Their Causation.

1085. One of the most important observations bearing upon this subject is that of Fol (No. 40, 1877, p. 659) relating to the irregular impregnation of the ovum. As a rule, only one spermatozoid is utilised for this purpose, but it happens occasionally, at least in the case of the sea-urchin and starfish, in which he made the observations, that several gain entrance owing to the vitelline membrane not having spread round the ovum so as to protect it. Such ova divide irregularly and a monster results.

Geoffroy St. Hilaire (see Bibliog.) showed that violent shaking or partial varnishing of the hen's egg is a fertile source of irregular development.

Dareste and Panum (see Bibliog.) have extended these observations, and their results point to various procedures being competent to induce monstrosity. Of all expedients adopted by them, however, those of **variation of temperature** and **heat irregularly applied to the egg** were most fertile in positive results. Variations of temperature from above 45° C. to below 30° were effectual in numbers of instances. Where the heat was applied to one part of the egg more than to another, the defect was often noticed in the *vascular system.* The blood-islands remain separate from one another and from the heart. The blood is thus rendered poor in corpuscles, and a dropsical condition of the embryo sets in.

Maternal impressions have often been taxed with causing certain forms of monstrosity, such as that of a headless child, from the pregnant mother having witnessed an execution; a pigmented and hairy patch on the skin, from the mother having been frightened by a mouse; or a web-handed condition, from the mother having been present when the fingers of a corpse were being tied together. Although there is some basis for such allegations, yet, in most cases, they should be accepted *cum grano.*

Dreams have also been asserted to have a like effect upon the fœtus; but here as before there is abundant opportunity for display of the *post hoc ergo propter hoc* fallacy. It would be naturally in the early months of pregnancy that such causes, if they are operative at all, would exert their greatest influence.

Dog-breeders assert that the sight of a mongrel at the time of conception, in the case of the bitch, sometimes influences the progeny deleteriously.

HEREDITARY TENDENCY.

Malformations are decidedly hereditary. Not only will the same mother sometimes bear a succession of malformed children, but certain peculiar features of malformation, such as polydactylism, have been known to run in families for a series of several generations. The majority of malformed fœtuses belong to the female sex; and often a single individual shows a multiplicity of aberrations.

INDIVIDUAL MALFORMATIONS CAUSED BY INTERRUPTION IN THE EARLY EVOLUTION OF THE EMBRYO.

Fissures of the Body Wall.

When the human ovum is fertilised changes take place in it which culminate not only in the production of the embryo, but in that of its enveloping membranes. The yolk, vitellus, or protoplasm undergoes cleavage and a round mass of cells results (mulberry mass).

Soon, however, these cells come to arrange themselves in a single layer on the interior of the zona pellucida or vitelline membrane. This cellular layer is the primitive epiblast. It encloses a cavity, and to it the term **blastodermic vesicle** is often applied. Within it is the true yolk, a semi-liquid albuminous substance.

At one part on this blastodermic vesicle an opaque spot in course of time shows itself. Consisting as it does at first simply of an accretion of the undifferentiated mass of cells common to the whole vesicle, it nevertheless marks out the seat of formation of the future embryo, and is known consequently as the **area germinativa.** It splits subsequently into two layers, the **epiblast** and **hypoblast.** In course of time a third is imposed between the two, the **mesoblast.**

From the vitelline membrane small tufts grow outwards. These, becoming attached to the uterus, serve as a temporary chorion.

The embryo soon develops a head and tail end from a fold of the epiblast showing itself at each extremity. When the mesoblast has spread for some distance between the other two layers it splits, the inner half being known as the **splanchno-pleure,** the outer as the **somato-pleure.** The space between the two is the primitive **pleuro-peritoneal cavity** or body cavity. Part of this becomes the pleuro-peritoneal cavity of the fœtus.

The fact that this cavity in the case of the higher vertebrates appears in the mesoblast, taken by itself, would seem to indicate that it is purely a mesoblastic structure. There is evidence to prove, however, that, in the invertebrata, it arises as a diverticulum from the primitive alimentary canal or archenteron. For, as shown by the Hertwigs (No. 571), and as emphasised in this country by Bland Sutton, the coelom or body cavity of the invertebrate, which is generally held to be the homologue of the pleuro-peritoneal cavity of the vertebrate, is in its earliest state an outgrowth from the primitive intestine, and hence gets a lining of hypoblast.

Against this view, according to F. Balfour (No. 572, i. p. 343), are to be reckoned the facts that (1) the mesoblastic plates in the vertebrate are solid; and (2) as a consequence the pleuro-peritoneal cavity never communicates with the intestine. That the cellular investment of the peritoneum or pleura is hypoblastic holds true probably only in the sense of the whole mesoblast being an offshoot from the hypoblast. Nevertheless, in view of the peculiarly epithelial character of the cells of the ovary, the possibility of their representing a far-back connection with the hypoblast ought not to be forgotten.

When the cleavage of the mesoblast is somewhat advanced, a second fold, running concentrically with the semilunar shape of the first, appears on the epiblast a little way in front of the head-fold of the embryo. This is the commencement of **the amnion.** It is composed of the epiblast and the layer of mesoblast in contact with its inner surface. It continues to grow, stretching backwards over the head of the embryo, and in course of time meets a similar fold from the tail end.

Identical folds rise up from the sides of the area germinativa, and the whole of these come into contact over the back of the embryo. At the points of contiguity a fusion takes place, the lower layer becoming the **true amnion** and the space enclosed within it the amniotic cavity. The upper or outer layer is the **false amnion.** The name **subzonal membrane** is applied to the latter by Turner from its position immediately beneath the zona pellucida. It is entirely separated from the amnion by the common pleuro-peritoneal space, and in course of time becomes one of the layers of the permanent chorion. It forms, in fact, the epithelial covering of the villi of the fœtal placenta.

Whilst the amnion is thus enclosing the embryo above, the mesoblast is being pushed farther and farther around the blastodermic vesicle, and so separates its cells into an inner and outer layer. And as it pushes its way forwards it continues to split almost simultaneously into two layers. The space between the layers is of course the continuation of the pleuro-peritoneal cavity. The splitting of the mesoblast finally reaches the lowest, or, if we may so express it, the southern pole of the blastodermic vesicle, and thus completely divides the mesoblast into two. The whole of the cavity included between its layers becomes obliterated as the amniotic liquid increases in quantity, and compresses it, unless the part included within the body of the embryo.

The head-fold, tail-fold, and lateral borders of the embryo meanwhile have been pinched inwards, so that they compress part of the blastodermic vesicle and convert it into a tube-like structure running in the long axis of the embryo and as yet shut at each end. The tube-like cavity so enclosed is the **primitive intestine.** The layer of hypoblast included in the infolded body wall becomes the epithelium of the future œsophagus, stomach, and intestine; while the corresponding mesoblast furnishes the muscular and connective tissue elements of the same.

Up till the end of the sixth week, however, the blastodermic vesicle and the intestine are not completely separated. A channel remains between them known as the **omphalo-mesenteric duct,** while the blastodermic vesicle, now reduced in size, goes by the name of the **umbilical vesicle.** After the sixth week this duct becomes obliterated and the umbilical vesicle disappears.

The first malformation to specify is where a greater or less portion of the duct remains permanently open in extra-uterine existence. The malformation is known as *Meckel's diverticulum* or *diverticulum ilei.* The diverticulum branches off at right angles to the ileum usually at a point from 1 to 3½ feet above the ileo-colic valve. It is placed opposite the mesenteric attachment and varies in length. It terminates occasionally in a cord fixed by one end to the umbilicus, and is composed of the same coats as the intestine. It may become a source of danger from lodging foreign bodies, or, when attached to the umbilicus, by causing strangulation of a mass of intestinal convolutions which have slipped underneath.

A portion of the common pleuro-peritoneal cavity is cut off by the above folding-in of the walls of the embryo. This in time becomes the *pleuro-peritoneal cavity of extra-uterine existence*, divided into two by the subsequent ingrowth of the diaphragm.

Important changes are also taking place towards what will be the pelvic region of the fœtus. A small sausage-like projection is pushed out from the primitive hind-gut. This is the **allantois.** It enlarges rapidly, makes its way into the primitive body- or pleuro-peritoneal cavity, and becomes applied to the subzonal membrane. It carries blood-vessels in its walls, the expansions of which become in due course the permanent vessels of the chorion and placenta, while their trunks furnish the umbilical arteries and vein. The interior of the allantois is filled with the allantoid liquid. The body walls are now being pinched in farther and farther, and finally coalesce in the middle line. The laminæ laterales of mesoblast simultaneously are being pushed inwards in a like direction, and are increasing in thickness. The muscular and rigid tissues of the trunk are ultimately formed out of them.

The last part of the body wall to unite is in the neighbourhood of the umbilicus, and from this there issue about the end of the third to the fourth week the omphalo-mesenteric duct and allantois with its enlarging vessels. The cleft up till this time existing in the body wall, where these structures make their exit, should be entirely closed by the end of the sixth to the eighth week.

As the body wall thus envelops the allantois, part of the allantois is left within the abdomen. The deepest portion of the enclosed part becomes the **urinary bladder,** the remaining portion is the channel known as the **urachus.** The urachus in time is converted into a solid cord, the future **middle vesical ligament.**

It sometimes happens, however, that the urachus remains pervious and communicates with the bladder. When this abnormity exists the channel of the urachus may become distended into a cystic cavity often larger than the bladder itself. The malformation is known as **urachus cyst** (Fig. 541).

The part of the allantois outside the body wall atrophies, while its vessels become embedded in the Wharton's jelly. The vessels thus embedded, with the reflection of the amnion as an external investment, constitute the **umbilical cord.**

From the fact that the body wall has to cover in the important cavities of the thorax and abdomen it is evident that there is the possibility of the closure not being completely effected, and of very disastrous malformations resulting therefrom. Such a failure to complete the anterior wall of the trunk is a common deformity. It may be complete or partial. The various defects due to it have specific names applied to them, and are as follows :—

(1) **Thoraco-Gastro-Schisis.**—In this the body cavity remains quite unclosed and the viscera are all more or less visible through the fissure. The funis may be absent, and in such case the umbilical

vessels pass directly to the placenta. Sometimes the peritoneum with the amnion stretched over it constitutes a sort of sac covering the abdominal viscera, while loops of intestine or portions of the liver, spleen, stomach, etc., protrude through the aperture.

(2) **Gastro-Schisis** or **Fissura Abdominalis.**—The thorax is closed and the abdomen left open.

(3) **Congenital Hernia Funis.**—This is the smallest of the fissured conditions of the body wall. The defect is at the part last to be closed in. A protrusion of a coil of intestine covered by peritoneum takes place; the cord is located usually at the apex of the protrusion. Sometimes the defect is not in the middle line but to one side.

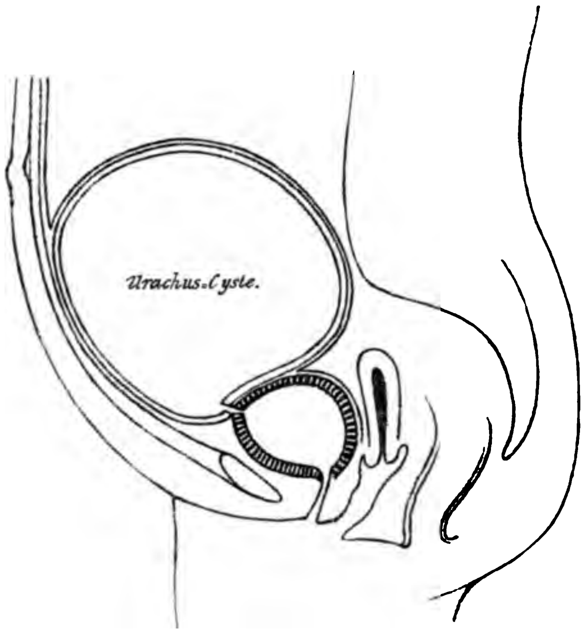


FIG. 541.—URACHUS CYST.

This condition must not be mistaken for acquired hernia umbilicalis, in which the closure of the wall is complete, but where a yielding of the tissues takes place.

(4) **Ectopia, Ectropium,** or **Ecstrophia Vesicæ.**—The abdominal wall may be closed in the neighbourhood of the umbilicus, while a fissure persists either above or below it. If below, it is usually accompanied by defect or absence of the anterior wall of the bladder,

while its posterior wall is everted by the intestine getting behind it, and protrudes from the aperture. The mucous membrane begins to granulate and is converted into a red fungating mass. The ureters open in their usual situation and the urine makes its way out of the defect. The genital groove in the penis is unclosed and the external genitals are ill developed.

Extensive fissura abdominalis occurs only in the female, ectopia vesicæ much more frequently in the male.

(5) **Fissura Sterni.**—Sometimes the thoracic defect is represented by a mere fissure or cleft of the sternum. If the defect is wider, if it be confined to the thorax, and if the heart covered by the pericardium protrude from it, the term **ectopia cordis** is applied to the malformation.

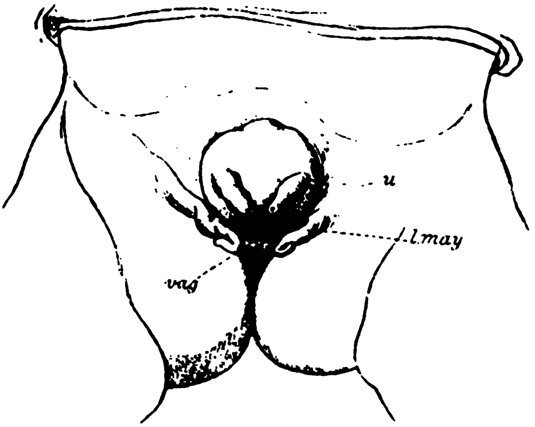


Fig. 542.—Ectopia Vesicæ.

Malformations connected with the Branchial Arches and Clefts.

1086. The commonest of all malformations are those resulting from imperfect union in front of the parts developed out of the first branchial arch.

In the neck of the embryo at an early period of existence there are to be seen four clefts known as the **branchial or visceral clefts.** They pass from the throat internally through the soft parts and skin. They seem to be formed by a dehiscence of the cells of the part, beginning in the hypoblast, next piercing the tissues of the mesoblast, and lastly affecting the epiblast.

No sooner has a cleft appeared than the upper border rises into a ridge or fold known as a **visceral** or **branchial fold.** There are five visceral folds to the four visceral clefts.

In each of the first three there is a rod of cartilage. The term **branchial arch** is sometimes applied to the entire structure formed from each set of visceral folds on the two sides.

It is with *the first* of these arches that we are at present concerned, as it is mainly out of it that the jaws and soft tissues appertaining thereto are evolved. Its two segments meet in the middle line, and thus establish the rudiments of the future **inferior maxilla.** From the concavity on each segment a bud-like process projects inwards; and the two buds tend to meet in the middle line. They never unite completely, however, but leave a vacuity, which is filled up by a process of tissue which grows down from the frontal region. This process bears with it rudiments of bone, skin, and other soft parts. The bony rudiments carried downwards comprise the two *ossa intermaxillaria*, within each of which, later on, are developed two incisor teeth. Some time after this frontal process has taken up its position between the two buds given off from the arch, the three parts coalesce, and out of them the **upper jaw** is constructed. Externally the fusion is so complete in Man that the point of junction, at the time of birth, is not recognisable. The line of junction internally, however, with the **hard palate,** which, it should be remembered, is developed within a plate of cartilage on each side, is plainly visible.

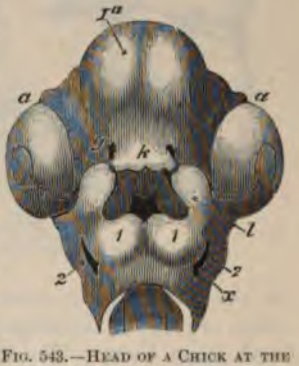


FIG. 543.—HEAD OF A CHICK AT THE SIXTH DAY SEEN FROM BELOW (after Huxley).

(*Ia*) Cerebral vesicles; (*a*, *a*) eye in which the remains of the choroid slit can still be seen; (*g*) nasal pit; (*k*) fronto-nasal process; (*l*) superior maxillary process of first visceral arch; (1, 1) inferior maxillary process or first visceral arch; (2, 2) second visceral arch; (*x*) first visceral cleft between first and second visceral arches. The mouth is seen enclosed by the fronto-nasal process, the superior maxillary processes, and the first pair of visceral arches.

The space between the upper and lower jaws thus brought into existence becomes the future **mouth.**

The fusion of the parts entering into the structure of the upper jaw occurs about the middle of the third month. The junction, however, between the three parts often fails, and a fissure is consequently left. The fissure may be bilateral or unilateral, and extends to various depths, the terms **cheilo-gnatho** or **palatoschisis** being used jointly or singly to indicate the amount of defect (χεῖλος, lip; γνάθος, jaw; and *palatum*, palate).

Harelip or Cheiloschisis (*Labium Leporinum*).

This is one of the commonest of the above defects, and consists of a lateral splitting of the upper lip. The cleft is lined by mucous membrane and may extend into the nostril. Sometimes it is represented by a mere notch or cicatrix. The cleft is single or double, and in two-thirds of the single cases it is on the left side. When the cleft is double the part of the lip attached to the intermaxillary bone is often ill developed, and projects forwards as an unsightly mass (Fig. 544).

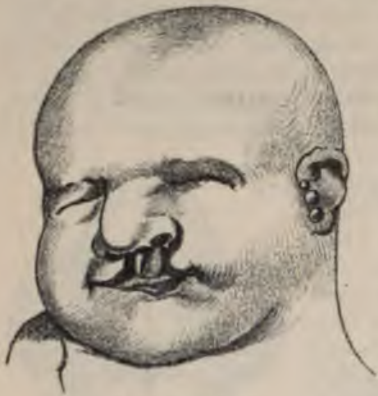


FIG. 544.—HARELIP.

In extreme cases not only does the cleft extend through the lip, but also into the hard palate, and even down as far as the throat. In such cases it passes between the outer incisor tooth and the canine.

If the cleft is double, not only is the part of the lip attached to the intermaxillary bone deficient, but the intermaxillary bones and vomer are usually also abortive. There is thus left a space on the roof of the mouth divided by the rudimentary vomer. Forming the anterior boundary of the space are the ill-developed intermaxillary bones, often with only two teeth upon them. The cleft, further, may extend to the soft palate, in which locality it is always single.

Sometimes the defect influences only the hard and soft palates, or it may be the soft palate alone. The condition in these cases is known simply as **cleft-palate.**

Schistoprosopia and Aprosopia (πρόσωπον, *the face*).

In some cases the defect extends throughout the entire face. A fissure runs up on each side of the nose towards the orbit continuous with the cleft in the lip (Fig. 545). At other times the lip may remain uncleft, while a shallow fissure runs through the face. Occasionally it happens that the entire face is in great part wanting, a huge gap intervening where the face ought to be.

Agnathia (γνάθος, *the jaw*).

By this is meant a congenital absence of the lower jaw and its attached soft parts. It is due to arrested development of the two sides of the first branchial arch. The lower part of the face seems cut away and there is an approximation of the ears (synotia, Fig. 546).

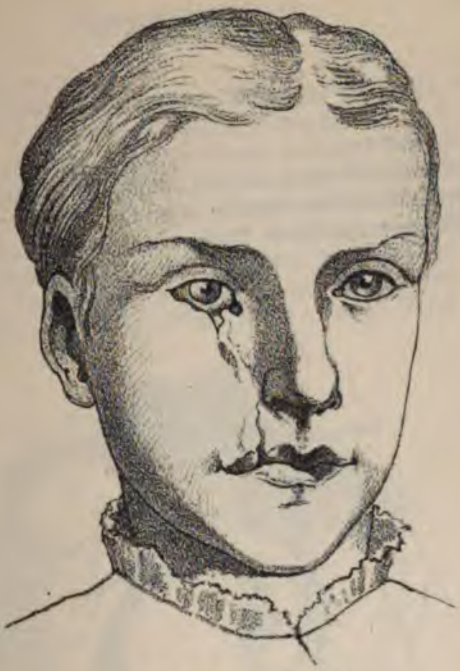


FIG. 545.—SCHISTOPROSOPIA.

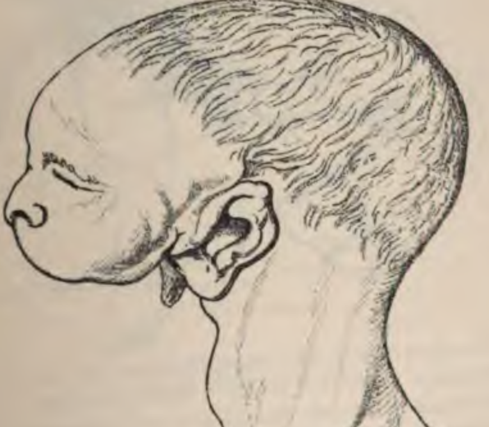


FIG. 546.—AGNATHIA.

Fistula Colli Congenita.

This is a malformation caused by the persistence in extra-uterine life of one or more of the branchial clefts. It is usually the third or fourth, but occasionally the first or second.

The commonest site of it is on the right side of the neck from 1 to 3 ctm. above the sterno-clavicular articulation. Sometimes, curiously, it occupies the middle line. The fissure is lined with mucous membrane and from it mucus exudes spontaneously or on coughing. A probe can be pushed into it, which usually finds its way down to the pharynx, larynx, or neighbourhood of the hyoid bone. The sac ends occasionally in a blind extremity.

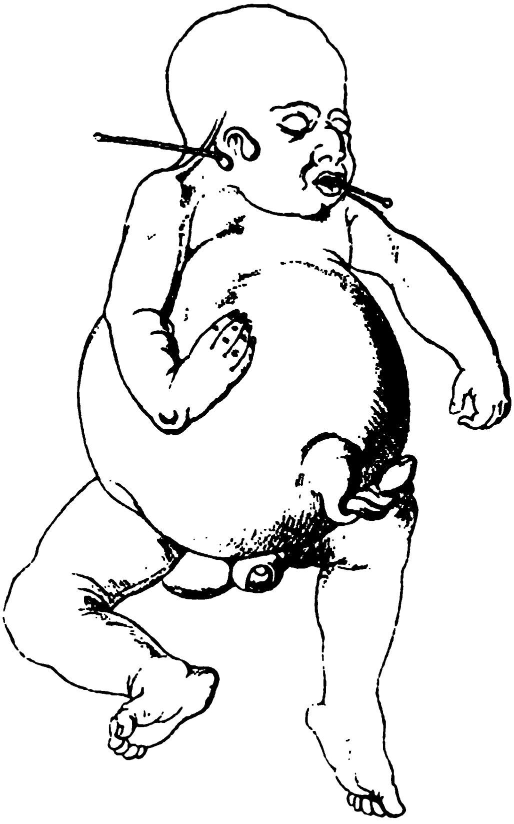


FIG. 547. FISTULA COLLI.

MALFORMATIONS DUE TO DEFECTIVE DEVELOPMENT OF THE BONES OF THE SKULL AND SPINE.

1087. In the case of the skull it is generally the bones of the vault which are wanting, and very often the defect is accompanied by a similar absence of the scalp. The vacuity caused thereby may comprise the entire vault (acrania) or may be limited to the parietal region. In the former case the basilar process of the occipital is exposed and forms the floor of the space; in the latter the frontal and occipital bones are approximated and at an angle, while the base of the skull is similarly bent. There are often quantities of membranous tissue, probably the remains of the dura mater, lying in the gap and adherent to the base. The skin terminates abruptly at the edge in the majority of cases, but sometimes the scalp is entire, and lies in contact with the base of the skull or encloses a number of cyst-like cavities. The face assumes a peculiar toad-like aspect.

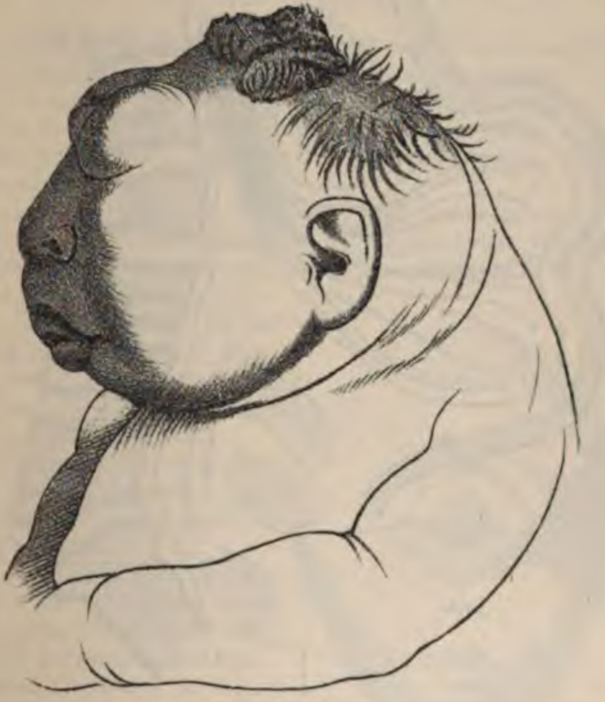


FIG. 548.—ACRANIA.

The brain in most examples is entirely wanting. Sometimes a piece of cerebrum is found lying in an isolated position enveloped in membranes. A portion of the cerebellum and a rudimentary pons may exist, but in cases where the foetus has become viable the medulla oblongata is preserved. Such foetuses when born may live for several days. In other respects they behave very much as those normally constituted.

The spinal cord usually appears to the naked eye to be normal, and microscopically often does not present any great abnormality.

The cranial nerves are always recognisable, even where the brain is completely absent, so that they appear to spring from the fibrous tissue covering the base. It has been asserted, however, that the optics and retina, where the eyeballs are completely developed, are destitute of nerve fibres.

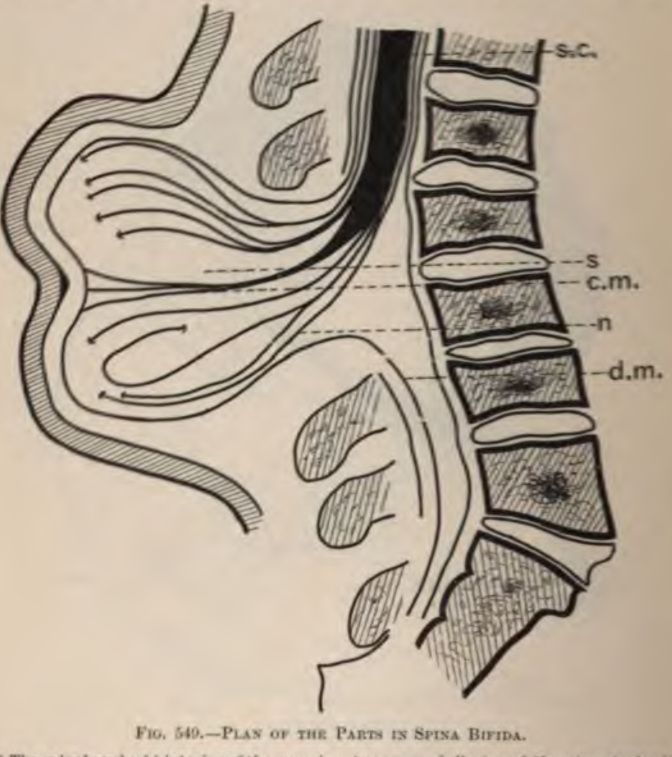


Fig. 549.—Plan of the Parts in Spina Bifida.

(*s.c.*) The spinal cord ; (*s*) interior of the sac ; (*c.m.*) conus medullaris and filum terminale attached to the dimple-like depression on the sac ; (*n*) nerves of the cauda equina drawn into the sac ; (*d.m.*) dura mater forming the sac.

It is seldom that, in advanced acrania, the defect is single. Hare-lip, spina bifida, and other deformities are often simultaneously present.

The causes of the malformation have been alleged to be various. Thus a collection of liquid in the cerebral vesicles prior to the fourth month of gestation has been stated to induce it. Pressure of the head-fold of the amnion (see Sect. 1085) has been blamed, while a too sharp curve at the head end of the embryo has also been reckoned as a cause.

Local deficiencies sometimes occur in the cranial vault, more particularly in the occipital region and at the root of the nose. The state of the parts is described under **Encephalocele** and **Meningocele** (Sect. 250).

Spina Bifida (see Sect. 251).

MALFORMATION DUE TO THE PRIMITIVE CEREBRAL VESICLE REMAINING UNDIVIDED.

1088. The monstrosity resulting from this cause is known as **cyclopia** or **synophthalmia.** The characters it bears are as follows:—

In the region of the root of the nose there is a single orbital space. This in some cases is very small and may not show a trace of an eye. In others it is larger and contains a rudimentary single eye, or two placed in contiguity.

Between these three alternatives there are several grades. Thus there may be a shrivelled eyeball, a single eyeball, but widened and containing a double lens or double cornea placed side by side.

The *nose* is either completely absent or is represented by a proboscis-like appendage of skin and soft tissues continuous with that of the forehead and sometimes of considerable length.

The *frontal bone* and *upper jaw* are both under-developed; the opening of the mouth is small or completely absent.

In place of the two *cerebral hemispheres* there is a single cerebral vesicle pointed anteriorly and undivided by anything in the shape of a longitudinal fissure or falx. There is usually also an absence of *convolutions* and of a *corpus callosum.* The *basal ganglia* are rudimentary.

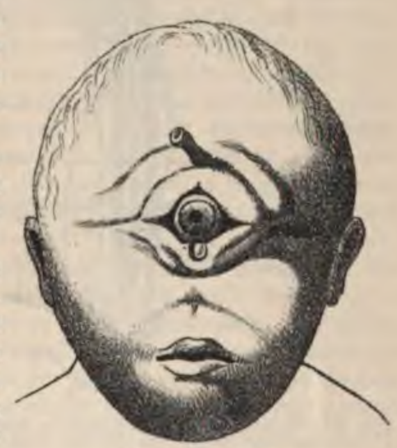


FIG. 550.—CYCLOPIA.

The *optic chiasma* and the *optic nerves* are often wanting and in some cases there is a single nerve; the olfactories are always absent.

In other respects the fœtus may be normal.

The malformation depends upon defective evolution of the primary cerebral vesicle, in consequence of which a single optic vesicle is evolved or the two lie in close contact. It is a common deformity in the calf and lamb.

MALFORMATIONS OF THE HEART AND BLOOD-VESSELS.

1089. The first representative of the heart in the embryo takes the shape of two small vesicles found towards the head end and held in contact with the under aspect of the primitive œsophagus by membranous attachment. These two vesicles lie in the mesoblast, and shortly after they come into existence fuse together so as to form a single cavity. This cavity assumes the character of a tube, which lies close under the œsophagus and runs parallel with it.

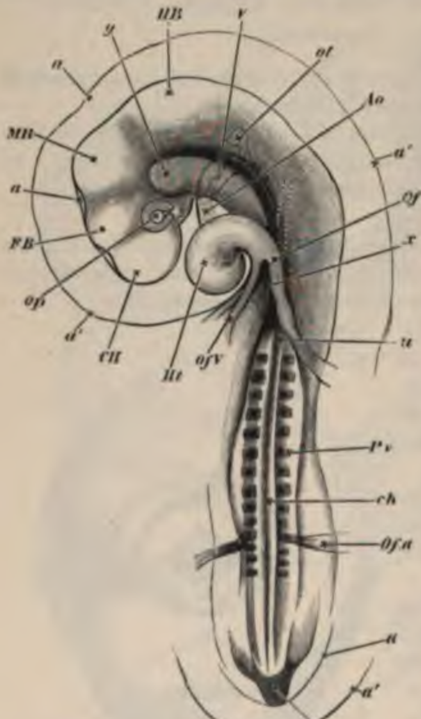


FIG. 551.—EMBRYO CHICK OF FIFTY-FOUR HOURS, SHOWING THE HEART (*Ht*) IN THE STAGE OF SIGMOID BEND.

It is early endowed with contractile properties, and vessels become attached to it. Thus anteriorly it forms a slight bulging known as the **truncus communis arteriosus** or **bulbus arteriosus**; while posteriorly it receives the **omphalo-mesenteric veins.**

The truncus communis arteriosus divides into two branches, the primitive aortæ, which course backwards round the œsophagus to unite on the dorsal aspect of the same, and, close by the spine, into the single dorsal aorta. Within the arch formed by each of the primitive aortæ embracing the œsophagus the rudiments of the future large arteries of the head, upper extremities, and lung are laid down.

The next phase in the development of the future heart and arteries consists in the fusiform tube representing the heart being constricted by an annular furrow which marks it off into two chambers continuous with each other. The posterior of the two, receiving as it does the venous blood, is the **primitive auricle**; the anterior is the **primitive ventricle,** with the truncus arteriosus emerging from it.

At the same time this tube, which up till now has maintained a straight direction in the long axis of the embryo, takes a bend upon itself, the so-called "sigmoid bend," whereby the primitive ventricle comes to lie the lower (anterior), the auricle the higher (posterior) of the two cavities (Fig. 551, *Ht*).

Malformation No. 1 in developmental sequence is of rare occurrence, and consists in an arrest of development of the organ after a single auricle and ventricle have come into existence.

Then follows the separation of the primitive auricle and ventricle, each into two cavities, by the development of their respective septa. The ventricular septum grows from the apex upwards, the last portion to be covered in being above—the pars membranacea as it is called in the fully-developed organ. This septum begins to show itself by about the sixth week and should be complete by the eighth. The septum often fails at the spot just indicated as being the last to be completed, and a patency remains, as in the chelonia and scaly reptiles, through adult life.

Malformation No. 2 is therefore the **perforate intraventricular septum.** Even with a huge aperture between the two cavities the individual may reach adult life.

The auricular septum grows downwards and from the anterior aspect, instead of upwards. It appears about the eighth or ninth week and not until the development of the ventricular septum is completed. By the end of the sixth month it is formed above, but is still widely defective below. A membranous fold now grows upwards and partially closes in the defect by uniting with the portion descending from above. The aperture, however, remains open even for some time after birth as the foramen ovale. It sometimes remains permanently open and may allow blood to pass from one auricle to another.

Malformation No. 3 is therefore **patent foramen ovale.** This defect is a common one, and the intermixture of the blood caused by it often occasions great cyanosis; but in a large number of cases the aperture is guarded by a valve-like fold of endocardium which prevents regurgitation taking place.

The two embryonic aortæ, as aforesaid, run over the sides of the primitive œsophagus to coalesce behind in the single dorsal aorta. Each forms an arch in bending forwards and backwards, and within the concavity of this arch are developed four other vascular arches out of which the largest arteries are in whole or in part constructed. There are thus five vascular arches in all; but they are never present at the same time, for when the fifth comes into existence, the first and probably the second have been removed. Each arch springs from an aorta on the ventral aspect, and enters the corresponding aorta on the dorsal aspect. The segments of the aortæ intervening between the points from which they spring are known as the **ventral aortic roots,** and those intervening between the points at which they are inserted are called the **dorsal aortic roots.** The five arches correspond, moreover, to the five branchial ridges.

The truncus communis arteriosus up till the time when the ventricular septum is beginning to grow upwards consists of a single stem. It soon becomes divided by a septum which grows out from either side of its interior. The segments of the septum unite, and the

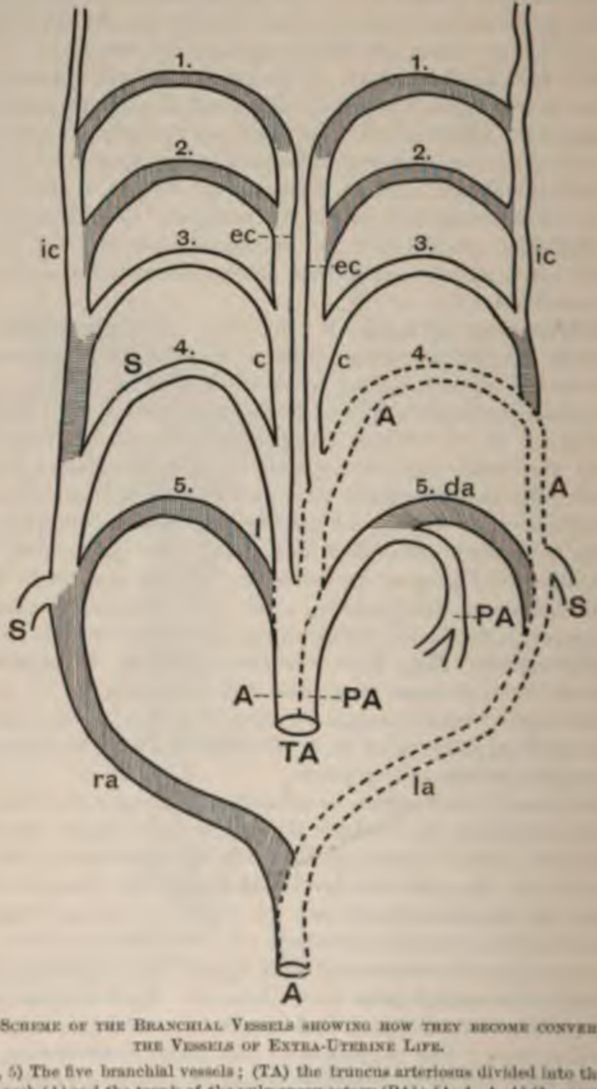


FIG. 552.—SCHEME OF THE BRANCHIAL VESSELS SHOWING HOW THEY BECOME CONVERTED INTO THE VESSELS OF EXTRA-UTERINE LIFE.

(1, 2, 3, 4, 5) The five branchial vessels; (TA) the truncus arteriosus divided into the first part of the aortic arch (A) and the trunk of the pulmonary artery (PA); (A, A, A, A) the construction of the permanent aorta; (*la*) the left primitive aorta; (*ra*) the right primitive aorta; (PA, PA) trunk and the two branches of the pulmonary artery; (*da*) ductus arteriosus; (I) the innominate artery; (S, S, S) the right and left subclavian arteries; (*c*, *c*) common carotid arteries; (*ec*, *ec*) external carotid arteries; (*ic*, *ic*) internal carotid arteries.

portion of the vessel to be last divided is that which lies nearest the heart. The one channel thus formed becomes the ascending part of the arch of the aorta, the other the main stem of the pulmonary artery.

Malformation No. 4 is where the septum fails to be completed, and a patency remains between the origins of the pulmonary artery and aorta. In the crocodile the aperture is permanent, and is known as the *foramen Panizzæ.*

The *first and second arches* disappear and take no part in the construction of the vessels of extra-uterine life. The *fourth left and part of the dorsal aortic root between the fourth and fifth* undergo great increase in capacity and form the *transverse part of the arch of the aorta.* The ascending portion of the permanent aortic arch is thus developed out of part of the truncus communis arteriosus. The *left fourth vascular arch* and *the left dorsal aortic root between the fourth and fifth* give rise to the *transverse part of the arch;* while the *descending part* is the continuation of the *left primitive aorta* downwards into the common dorsal aorta.

The *fourth right arch* and the ventral and dorsal aortic roots between the fourth and fifth, become transformed into the *innominate and first and second parts of the subclavian artery.* The *left subclavian artery* is an offshoot from the *left dorsal aortic root between the fourth and fifth arch. The third part of the right subclavian* is a lateral twig of the *right dorsal root between the fourth and fifth arches.*

The *common carotid* is the outcome of the enlargement of the *ventral aortic root uniting the third and fourth arches;* the *external carotid* is a dilatation of the *ventral aortic roots uniting the first and second and the second and third arches;* the *internal carotid* is an enlargement of the *third vascular arch* and of the *dorsal aortic roots between the third and second and second and first arches.*

The *fifth right arch* in the normal course of events vanishes in early embryonic life, and the *right dorsal aorta* is similarly removed, but sometimes both of these remain open, thus giving rise along with that on the left to a double aorta.

Malformation No. 5.—There is a double aorta. Both aortæ remain pervious and communicate above either with the fourth or fifth arch.

The *fifth left arch* becomes continuous with the stem of the *pulmonary artery* derived from the truncus arteriosus, and is mainly transformed into the *ductus arteriosus* or *ductus Botalli* conveying the fœtal blood from the pulmonary artery into the aorta. From the concavity of this fifth arch two branches are given off, the *right and left pulmonary artery stems.* When the extra-uterine circulation is established the ductus Botalli of course becomes impervious.

From the complex manner in which the large vessels of the neck and upper extremities are evolved out of the above embryonic rudiments, an infinite number of variations are rendered possible. These need not be further detailed.

MALFORMATIONS DUE TO DEFECTIVE FORMATION OF THE GENITO-URINARY APPARATUS.

1090. This class of malformations comprises those deviations from the normal which are dependent upon irregular evolution of

(1) The genital glands (testis and ovary);
(2) The genital canals (oviducts, uterus, and vagina);
(3) The external genitals.

Formation of the Genital Tubes and Glands.

Early in the course of development there projects from the mesoblast into the bay or angle of the pleuro-peritoneal cavity a cellular ridge known as the **intermediate cell mass.** It is composed of mesoblastic cells, and is of great importance from the fact that it is within it that the genital and excretory glands and canals are moulded.

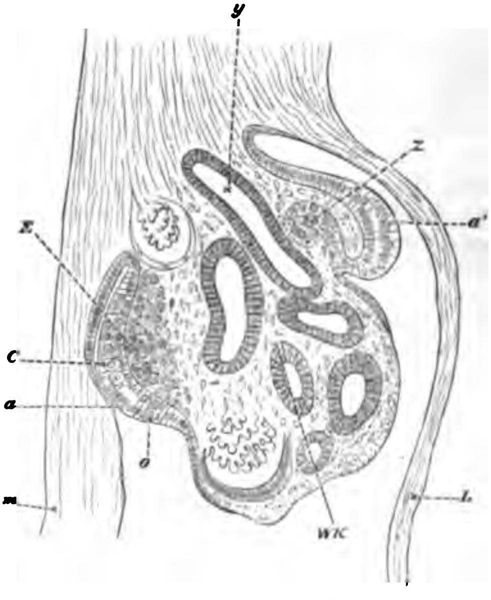


FIG. 553. SECTION OF THE INTERMEDIATE CELL MASS ON THE FOURTH DAY (after Waldeyer, × 160 DIAMS.)

(m) The mesentery; (L) somatopleure; (a') portion of the germinal epithelium; (z) duct of Muller; (a) thickened portion of the germinal epithelium in which the primitive ova (C and o) are lying; (E) modified mesoblast which will form the stroma of the ovary; (WK) Wolffian body; (y) Wolffian duct.

The excretory gland apparatus in the embryo consists of three parts, namely, the **pronephros** or **head-kidney**; the **mesonephros** or **Wolffian body**; and the **metanephros** or **rudimentary permanent kidney.** They are never functionally active at the same time, and the pronephros is the first of the three to be developed. The pronephros seems to be a much more active excretory organ in low types than it is in highly-organised vertebrates, so that in the mammalia it is mostly a rudimentary structure. Renal excretory functions are mainly effected by means of the Wolffian body.

The first rudiment of the various genital and excretory gland structures to show itself is *a cord-like column of cells* running in the long axis of the embryo and primarily occupying a dorsal position in the intermediate cell mass. When traced back to its earliest state it appears to be the result of a delamination of the epiblast whereby the ridge, after having severed its original connection with the epiblast, is pushed into the intermediate cell mass. Later on it is scooped out into a channel which goes by the name of the **segmental** or **archinephric duct.** This segmental duct is in communication with the pronephros anteriorly, and posteriorly opens into the cloacal junction of the intestine and allantois. It shortly afterwards splits into two, the **Mullerian** and **Wolffian ducts.**

In elasmobranchs the splitting is continued throughout the entire length of the duct. A solid offshoot is projected ventrally from the common channel, which, becoming hollow, constitutes the Müllerian duct. In the higher vertebrates (fowl, Balfour and Sedgwick) the anterior end of the Müllerian duct is the product of an involution of the peritoneum, while the posterior part alone is an offshoot from the segmental duct.

The Wolffian body possesses a tubular structure not unlike that of the permanent kidney. The Wolffian duct is in communication with it anteriorly, while posteriorly it discharges into the common cloaca.

The Müller's ducts open in the anterior (superior) abdominal region into the peritoneal or body cavity, while posteriorly they communicate with the cloaca, and later on with the anterior subdivided part of the cloaca known as the uro-genital sinus. The peritoneal openings are at first three in number, but only one of them remains permanently open. It is represented in adult life by the free opening of the Fallopian tube. A remnant of another opening is probably to be found in what is known as the **female hydatid,** a vesicular body attached by a long pedicle to the fimbriated extremity of the tube. It has been said that the triple opening of the duct anteriorly is the sole representative in the higher mammals of the pronephros or head-kidney.

In course of time a third tube appears. The lower end of the Wolffian duct becomes expanded, and a diverticular segment is cut off from the hinder part, which subsequently separates and is converted into a tube—the permanent **ureter.** It forms before the metanephros or kidney proper comes into existence. Posteriorly it opens into the allantois, while anteriorly it develops numbers of swellings with tubules growing out from them. These tubules burrow into the blastema which constitutes the rudimentary basis of the kidney and constitute the tubules of the permanent kidney.

At a certain period of development both the male and female glands are present, so that the embryo to begin with is a true hermaphrodite. Later on one or other disappears according to the sex.

On the ventral aspect of the intermediate cell mass the investing layer of cells becomes thicker than elsewhere. Certain of these cells also enlarge, assume a rounded shape, and sink deeply. They become the future ova, and by a thickening of the mesoblastic tissues at the point where they penetrate, the rudiments of the stroma of the **ovary** are laid down

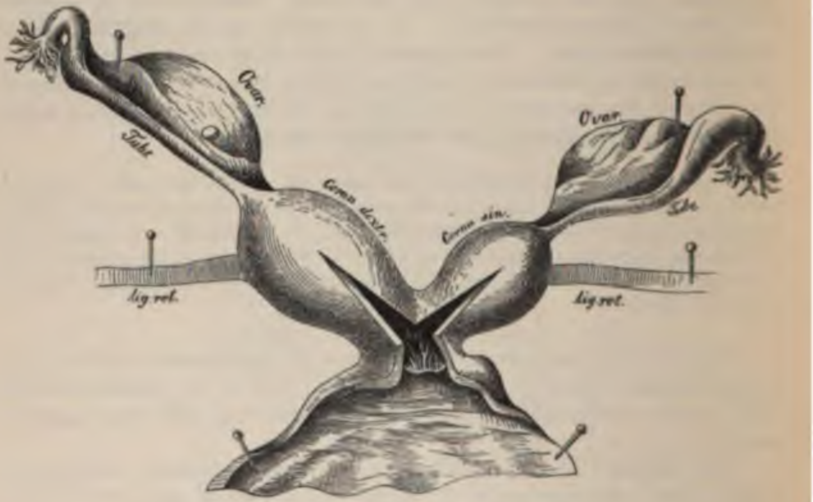


Fig. 554.—Uterus Bicornis.

On the dorsal and inner aspect of the same mass of mesoblast, cells arranged in rows with septa of connective tissue between them are to be seen. The rows of cells become the **seminal tubes,** and the connective tissue remains as the **stroma of the testis.**

The Wolffian duct in its future progress becomes chiefly a male appendage. It is converted into the vas deferens and common ejaculatory duct; while the vesiculæ seminales are developed out of diverticular prolongations from it.

In the female, on the other hand, it in great part becomes effete, the only remnant of it being the **canal of Gartner** (see p. 424).

The Wolffian body divides into a posterior or renal and an anterior or sexual portion. In the female the renal portion degenerates into what is known as the **paroophoron**, while the sexual portion is converted into the parovarium (see p. 423). In the male the renal portion becomes the organ of Giraldès, the sexual gives origin to the greater part of the epididymis.

Further Development of the Genito-Urinary Organs and the corresponding Malformations.

The Müllerian ducts anteriorly (superiorly) open into the peritoneal cavity by free extremities. Posteriorly they become continuous with the allantois cloaca. The two ducts at first enter the cloaca separately and are enveloped in a quantity of mesoblastic tissue, which binds them together into what is known as the **genital cord of Thiersch.** They subsequently fuse at their extremities, and for some distance upwards. Out of the single tube resulting from their fusion the vagina and uterus are evolved, while the portions of the duct beyond the point where the fusion has occurred become fimbriated at their

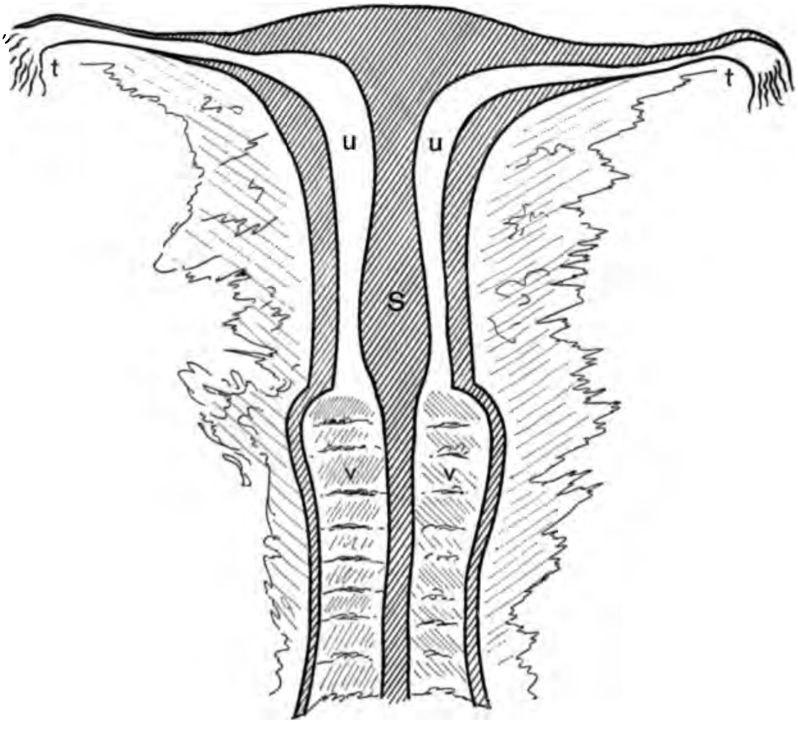


FIG. 555.—SCHEME OF UTERUS (ET VAGINA) BIPARTITUS.

(S) Septum dividing uterus into two cavities (*u*, *u*) and vagina into a double passage (V, V); (*t*, *t*) Fallopian tubes.

extremities and converted into the Fallopian tubes. Certain malformations of the vagina and uterus arise from a varying amount of junction of the lower ends. They are as follows:—

(1) The fusion may have occurred at a point too low down, in which case the uterus possesses a double horn (uterus bicornis).

(2) The ends of the tubes may have been bound together in the genital cord, but an absorption of the adjacent walls has not followed. A septum consequently divides the channel of the uterus and vagina into two (uterus et vagina septis, bipartitus, or bilocularis). In some cases the vagina alone is so divided.

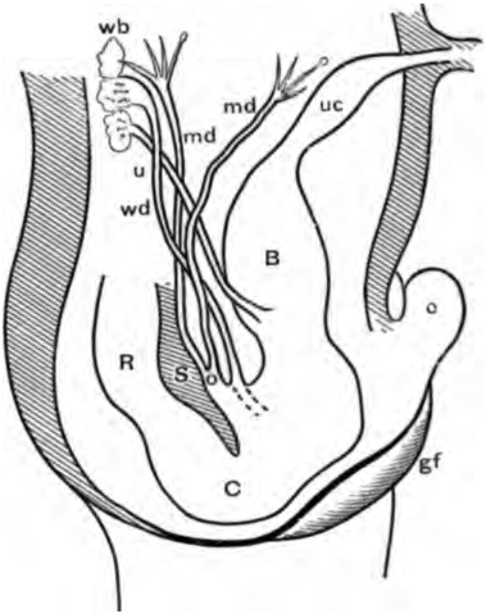


Fig. 556.—Diagrammatic Scheme of the Parts concerned with the Development of the Genito-Urinary and Rectal Passages at an Early Period of Embryonic Life.

(R) Rectum; (B) lower part of allantois constituting the future bladder. Both of these open into the as yet unperforated cloaca (C); (*uc*) urachus; (*md*, *md*) the two Muller's ducts; (*wb*) the three parts of the Wolffian body; (*u*) ureter; (*wd*) Wolffian duct; (*o*) coalescence of the Muller's ducts to constitute uterus and vagina; (*e*) genital eminence; (*gf*) genital fold; (S) the septum which has not as yet descended to subdivide the cloaca into the alimentary passage behind the genito-urinary in front.

(3) The parts of the Müller's ducts which go to form the uterus may have remained separate, but only one of them has enlarged, while the other has remained simply as part of the Fallopian tube. The malformation is known as uterus unicornis.

(4) In other instances still the vagina may alone have developed, the parts which go to form the uterus remaining unexpanded. The

uterus consequently is absent or rudimentary, and the tubes come off directly from the vagina.

Uro-genital Sinus and Rectum.—Up till the seventh or eighth week of intra-uterine life the genital, urinary, and intestinal tubes open into a common blind extremity or cloaca. The alimentary canal opens dorsally, the allantois ventrally, and the Wolffian and Müllerian ducts laterally. A septum of mesoblast now grows downwards which subdivides the common cloaca into an anterior and a posterior passage. The posterior passage is the rectum, the anterior the uro-genital sinus.

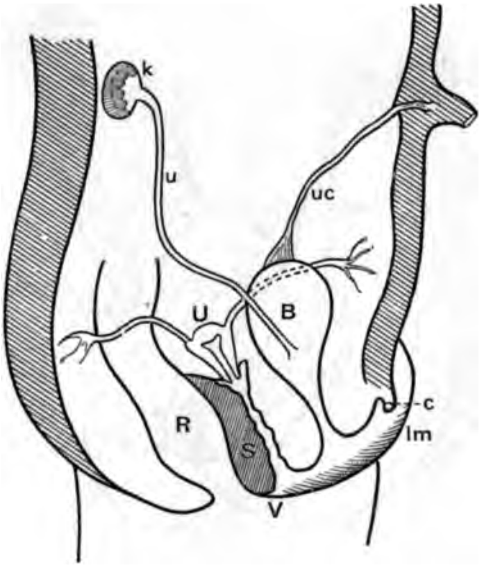


FIG. 557.—DIAGRAMMATIC SCHEME OF THE TRANSFORMATIONS UNDERGONE BY THE PARTS REPRESENTED IN FIG. 556 IN THE CASE OF THE FEMALE.

The septum (S) has now descended so as to separate the rectum (R) from the vagina (V) and to constitute the perineum below; (B) bladder with obliterated urachus (*uc*) above; (*u*) ureter; (*k*) kidney; (*c*) genital eminence converted into the clitoris; (*lm*) genital fold now become the labium majus; (U) uterus formed by the coalescence of the two Müller's ducts, now the Fallopian tubes.

The latter is so called because the allantois and Müller's ducts open into it.

The depression in the epiblast known as the proctodæum is forming about the fifth week, or shortly before the cloacal septum begins to show itself. It perforates the skin covering the cloaca about the sixth week, and allows the latter to open externally. The cloacal septum, however, which is being pushed more and more downwards, comes to divide the proctodæum into an anterior and a posterior aperture. The posterior aperture is the anus, the anterior is the external opening of the uro-genital sinus, while the septum between becomes the female perineum.

External Organs of Generation.—While these transformations have been going on in the internal parts connected with the genito-urinary organs, the external organs of generation have also been advancing in development.

There forms in front of the uro-genital sinus a little conical eminence (genital eminence) which as it increases in size becomes grooved on the under surface. This is the rudimentary **penis** or **clitoris** according to the sex. There also rise up two ridges of integument, one on either side of the uro-genital sinus, which, in the case of the male, coalesce in the middle line to give rise to the **scrotum,** but in the female remain apart as the **labia majora.**

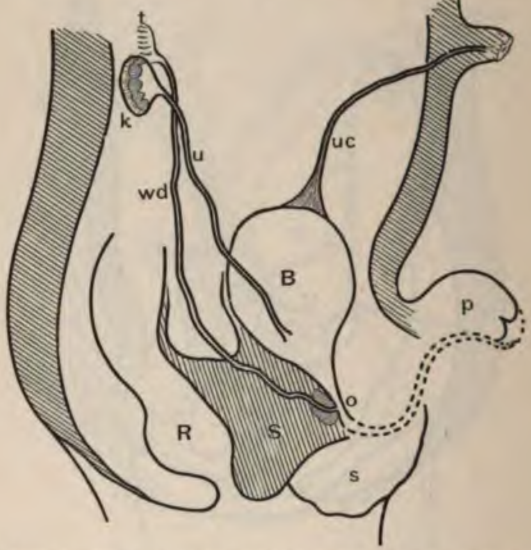


FIG. 558.—DIAGRAMMATIC SCHEME OF THE TRANSFORMATIONS UNDERGONE BY THE PARTS REPRESENTED IN FIG. 556 IN THE CASE OF THE MALE.

(R) Rectum; (B) bladder with the uro-genital sinus (*o*) forming the first part of the urethra. The dotted line in continuation of this represents the groove on the under aspect of the penis, by the closing in of which the anterior part of the urethra is constituted; (*uc*) urachus in a state of obliteration; (*u*) ureter; (*k*) kidney; (*t*) testicle; (*wd*) Wolffian duct now forming the vas deferens; (S) septum; (*s*) genital fold now converted into the scrotum. The Müller's ducts have vanished.

In the male the groove on the under surface of the penis closes over, to form a canal, the anterior part of the urethra, continuous with the uro-genital sinus. The sinus itself contracts down to constitute the posterior part of the urethra, and is continuous with the allantois, the lower end of which becomes **urinary bladder.** The remaining part of the allantois within the body becomes the **urachus,** and this undergoes obliteration. The Wolffian ducts remain patent as the **vas deferens** and **common ejaculatory duct**; while the lower ends of the Müller's ducts become the **prostatic sinus**, and the mesoblastic tissue around them (genital cord) the **prostate** itself.

In the female the progress of development is alike with that in the male up to the point where the rudimentary penis (clitoris) is developed with the folds of integument on either side of the uro-genital sinus. But here the resemblance ceases. The penis is arrested in its evolution and becomes the **clitoris**. The anterior part of the urethra, that part which in the male is constituted by the infolding of the groove on the under aspect, is entirely wanting, the short **urethra** being simply an extension of the neck of the bladder.

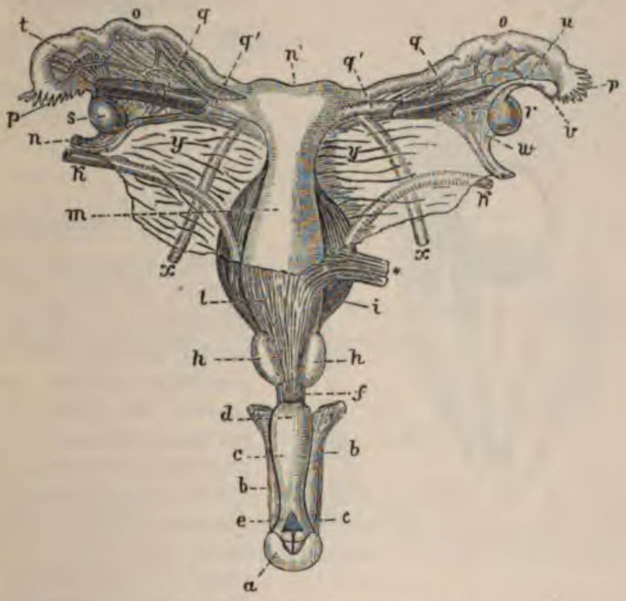


FIG. 559.—TRUE HERMAPHRODITE.

(*a*) Glans penis ; (*b*, *b*) corpora cavernosa ; (*c*) corp. cavernosum canalis uro-genitalis ; (*d*) its bulb ; (*e*) its anterior limb ; (*f*) pars membranacea canalis uro-genitalis ; (*h*, *h*) lobes of the prostate ; (*i*) urinary bladder ; (*k*) ureters ; (*l*) vagina ; (*m*) uterus ; (*n'*) fundus uteri ; (*o*, *o*) tubes ; (*p*, *p*) infundibula of same ; (*q*, *q*) ovaries ; (*q'*, *q'*) ligamenta ovarii ; (*r*) right testicle ; (*s*) left testicle ; (*t*) left parovarium ; (*u*) right parovarium ; (*v*) hydatid of latter ; (*n*, *w*) vessels of sexual glands ; (*x*, *x*) round ligaments ; (*y*, *y*) broad ligaments ; (*) muscular fibre of bladder and vagina going to wall of pelvis.

The uro-genital sinus remains open and expands into the **vestibulum,** while the coalesced Müller's ducts are pushed downwards as the **vagina** and **uterus.** The folds on either side of the vestibulum become the labia majora.

It is evident that from the complexity of these transformations there are many chances of their failing to be completed. As a matter of fact the genito-urinary and other pelvic organs are often malformed. These malformations are chiefly—

(1) HERMAPHRODITISM.

Definition.—By an hermaphrodite is meant *an individual possessed of the male and female genital glands.*

Hermaphrodites are often divided into two classes—that of **true hermaphrodites,** where the person is bi-sexual; and that of **false hermaphrodites,** where the sexual glands are single, and where the external organs of generation, merely, are the subject of the malformation.

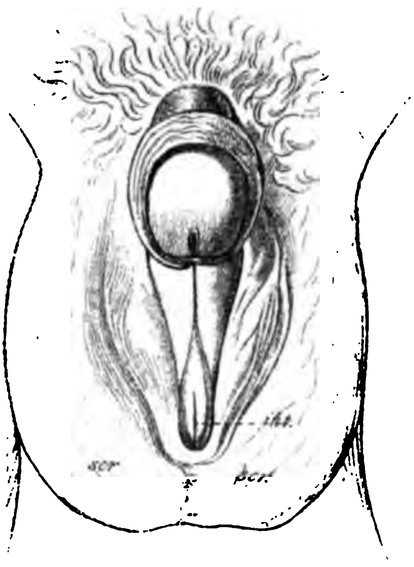


FIG. 560. EXTERNAL PARTS OF HERMAPHRODITE.
(*ins*) Entrance to uro-genital sinus; (*scr*, *scr*) scrotal folds.

True Hermaphroditism.

From the fact that the embryo at one period of its development possesses both sexual glands, there is the possibility of the condition passing into adult life as a permanent anomaly. A penis, prostate, and testicles are combined with ovaries, tubes, and uterus. The ovaries occupy their usual position, and the testicles lie somewhere in the broad ligament, or may have descended into what correspond to the labia majora. Sometimes the external organs are so anomalous as to render it difficult to say whether the individual is uni- or bi-sexual, or to which sex the person most inclines.

False Hermaphrodite.

Such a combination of the two sexes in one, however, is rare. Much more commonly the external organs of generation are the parts alone affected. The subjects of the malformation are always males, but the character of the malformation may be such that the external organs of generation come to resemble those of the female.

The malformation consists in the scrotal folds of integument failing to unite in the middle line. The spongy part of the urethra is absent, the penis is rudimentary, and the uro-genital sinus is left as a vagina-like orifice, usually, however, of small size. There may be a partial fusion in front, in which case the aperture left may correspond merely to that of a urethra. The testicles remain in the abdomen or slip down into the scrotal folds. Micturition takes place of course through the more or less transformed uro-genital sinus.

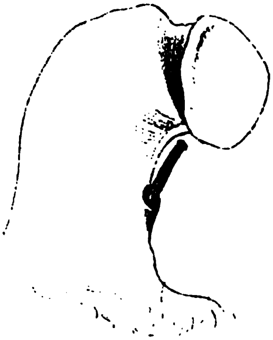


FIG. 561. — PENIS OF HERMAPHRODITE SHOWING ORIFICE OF URETHRA ON UNDER ASPECT.

(2) HYPOSPADIA AND EPISPADIA.

Sometimes the urethral groove on the under surface of the penis is only partially covered in, or terminates in an aperture at a point behind the glans penis. The condition is known as **hypospadia.**

A similar aperture or a groove communicating with the urethra is sometimes found on the dorsum penis. The defect goes by the name of **epispadia.** Its cause is not very apparent.

(3) ATRESIA ANI.

There is a series of malformations accounted for by a failure to complete the apertures of exit of the intestinal canal. They are sometimes known by the above generic title, and are as follows:—

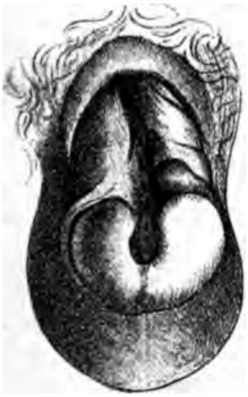


FIG. 562.—EPISPADIA.

(*a*) **Allantois Cloaca.** — This virtually corresponds to the condition of parts in the fourth week, namely, where the gut and the uro-genital passages open into a common space or cloaca, and where the integument remains imperforate. The large intestine is usually absent.

(*b*) **Common Open Cloaca.**—Representing as this does a stage still further advanced, the cloaca is perforate, but the septum has as yet not separated the alimentary from the uro-genital passages. From the fact that it is the permanent condition in many of the lower animals, it might be supposed to be a common defect in Man. This, however, is not the case; it is one of the rarest malformations of these parts.

(*c*) The gut opens into the genito-urinary passages. The septum has grown down so far, but not sufficiently to shut off the two passages completely, and the anus at the same time is imperforate. The bowel

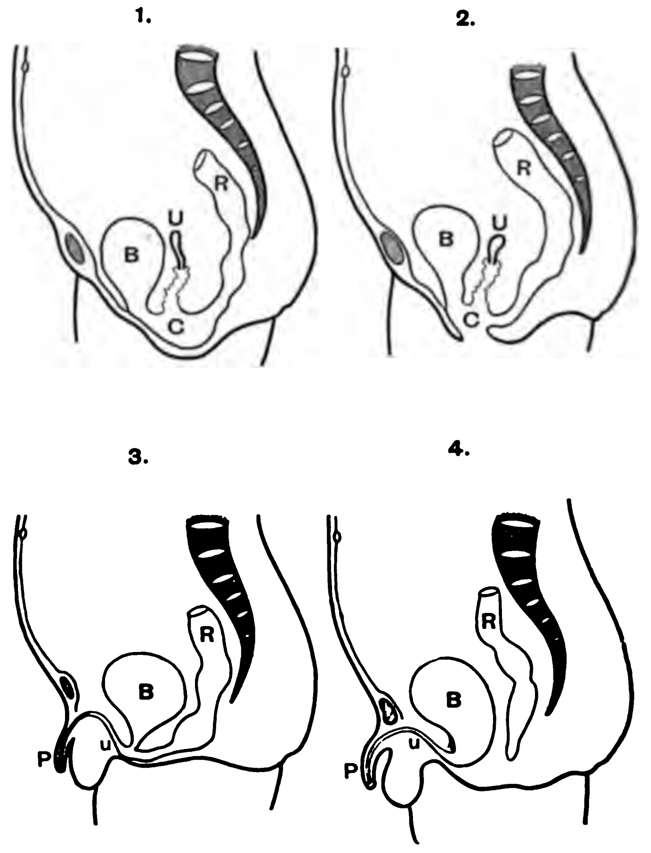


FIG. 363.—FOUR DIAGRAMMATIC SCHEMES ILLUSTRATING THE CHIEF MALFORMATIONS OF THE PELVIC ORGANS.

1. Allantois cloaca. (B) Bladder, (U) uterus, and (R) rectum opening into the unperforated cloaca (C).

2. Common open cloaca. (B) Bladder, (U) uterus, and (R) rectum opening into open cloaca (C).

3. Atresia ani urethralis. (B) Bladder, (P) penis, and (U) urethra, the rectum (R) opening into the first part of the urethra.

4. Atresia ani simplex. (B) Bladder, (P) penis, and (U) urethra. The bowel (R) ends in a blind extremity.

opens into the neck or base of the bladder, and the faecal discharge takes place per urethram. According to the point of communication the defect is recognised as **atresia ani vesicalis** or **atresia ani urethralis.**

In a second class of cases the point of exit is in the raphé scroti. Both classes occur in the male sex. In the female the gut may open into the vagina in close proximity to the hymen. In the vesical forms of the disease the aperture is so narrow that the subject of it soon dies from fæcal retention. In any case, where the communication is with the urinary passages, the condition proves fatal usually within a few days. The opening into the vagina is often wide, and defecation through the genital passages may remain as a permanent defect into adult life. As a rule there is no sphincter; in a few instances, however, such has been found.

Atresia Ani Simplex.—The septum has been completed and the two sets of passages are distinct, but the anus remains imperforate. The bowel ends in a blind extremity.

INCOMPLETE DEVELOPMENT OF THE INDIVIDUAL PARTS OF THE BODY.

1091. (1) **Amelus** (μέλος, a limb).—Failure of all the extremities. They may be represented simply by wart-like protuberances. The child often grows up into adolescence or it may be old age.

(2) **Peromelus.**—All the extremities stunted or misshapen.

(3) **Phocomelus** (*phoca*, a seal).—The hands or feet are well formed, but rest sessile upon the shoulder or hip.

(4) **Micromelus.**—Extremities well formed, but unusually small in all parts. It may be the upper or lower limbs which are the seat of the defect.

(5) **Abrachius.**—Entire absence of the upper extremities, while the lower are well enough evolved.

(6) **Perobrachius.**—The upper arm is normal, while the forearm and hand are stunted.

(7) **Microbrachius.**—Arms well proportioned, but unusually small.

(8) **Monobrachius.**—Failure of one upper extremity.

(9) **Sympus** (siren).—The inferior extremities are bound together, it may be, by a web-like appendage of integument; the feet are turned outwards or are absent; and there is usually some deformity of the pelvic bones. The external genitals sometimes are devoid of aperture; the anus is almost always imperforate.

(10) **Apus.**—Failure of lower extremities.

(11) **Monopus.**—One lower limb absent, often accompanied by some abnormality of the pelvic bones.

(12) **Peropus and Mikropus.**—Defective development or unusual smallness of one or both lower extremities.

(13) **Achirus and Perochirus.**—Absence or stunted growth of hand or foot. This is a rare deformity.

(14) **Perodactylus and Syndactylus.**—Stunted development and webbing of the fingers.

(15) Individual bones may be absent. Those which are most at fault are the *patella, fibula, radius, clavicle, scapula*, and the bones of a finger. The pelvis is often unusually small, although all its bones may be present.

MULTIPLE PREGNANCY.

1092. It is a question whether all cases of multiple pregnancy are to be traced to the same cause. It has been supposed—

(1) That several ova may be discharged from a Graafian vesicle;
(2) That several Graafian vesicles may burst at the same time:
(3) That a fertilised ovum may bear several germinal areas;
(4) That the single germinal area may split into two or more parts, each becoming an independent individual.

There are arguments in favour of each possibility. Thus the ovary often contains several corpora lutea; and it is now pretty well concluded that double and triple monsters result from the partial cleavage of a single germinal area, an observation which would tend to support the last of the above possibilities.

In the lower animals what is called **superfœtation**—that is to say, impregnation of two ova discharged at different times, often takes place. It is common in the sheep, but has not as yet been distinctly proved to occur in Man, and hence may be excluded as a possible cause.

Of all explanations that which supposes *a complete cleavage of a single blastoderm* is the one which has the greatest measure of support from observed facts. Partial cleavage is so common a defect that we are almost forced to conclude that it represents the arrestment of a natural phenomenon.

In twin births the relationship of the **placenta** and **membranes** is not always alike. The commonest varieties are as follows:—

(1) Complete separation of the placentæ and membranes.
(2) Chorion and placenta double, but united where they come in contact; only a single decidua reflexa.
(3) Placenta, chorion, and reflexa in common. The vessels of the umbilical cords anastomose in the placenta, and the twins are of the same sex.
(4) Where in addition to the arrangement present in No. 3 there is also a double amnion.

DOUBLE AND TRIPLE MONSTROSITIES.

1093. Although there have been many theories to account for these malformations, the one which is universally accepted at the present day is that which implies, to begin with, a single blastodermic area. This suffers incomplete cleavage.

In classifying them attention should be directed in the first place to *whether the vertebral column and skull are partially or completely separate.* If they are not perfectly distinct the next point to examine is *whether the duplicity lies anteriorly or posteriorly*, whether it affects the head or tail end of the axis or both.

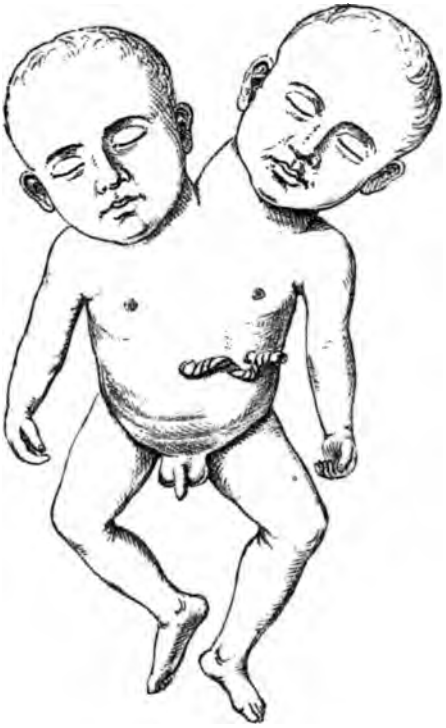


FIG. 564.—DICEPHALUS.

If the axis is perfectly cloven the individuals will be found to be adherent by some part of the body. They may be of equal size, or the one may be so much smaller and more stunted than the other that it looks like a parasite rather than an independent being. In other cases the parasitical twin may be included in the body of the autosite as a shapeless tumour-like mass. Sometimes it happens that the cleavage affects the rudiments of individual parts, and it ought to be noted that when this is so the earlier the period at which the cleavage takes place the more disastrous its effect. The following table will show at a glance the different degrees of this kind of monstrosity generally recognised :—[1]

(*a*) CLEAVAGE AFFECTING THE UNDIFFERENTIATED EMBRYO.

(A) *Complete Cleavage of Axial Structures.*

1094. 1. Development of twins equal.

- I. Thoracopagus (πήγνυμι, to bind).
  - (*a*) Xiphopagus.
  - (*b*) Sternopagus.
  - (*c*) Prosopo-thoracopagus, cephalo-thoracopagus, or syncephalus.
  - (*d*) Janiceps.
- II. Craniopagus.
- III. Ischiopagus.

2. Development of twins unequal.

- I. Acardiacus (amorphus, mylacephalus, acephalus, acormus, etc.).
- II. Thoracopagus parasiticus.
- III. Epignathus.
- IV. Teratoma.
- V. Inclusio fœtalis (abdominalis, subcutanea, mediastinalis, cerebralis, testiculi, etc.).

(B) *Partial Cleavage of Axial Structures.*

1. Duplicitas anterior.

- I. Double pituitary body.
- II. Clefts of the face and duplication of the mouth, etc. (diprosopus, distomus, diophthalmus, triophthalmus, tetrophthalmus, triotus, tetrotus, etc.).
- III. Dicephalus.
- IV. Pygopagus.

2. Duplicitas posterior.

Dipygus, cleavage of coccyx or of other parts of the pelvis.

(C) *Multiple Cleavage.*

Tricephalus, or it may be both the head and tail ends simultaneously bifid (Rhachipagus).

---

[1] The author begs to acknowledge his indebtedness in drawing up this table to the excellent summary of these malformations given by Ziegler (No. 337, p. 33) and by Birch-Hirschfeld (No. 117, p. 243).

(β) CLEAVAGE AFFECTING THE RUDIMENTS OF INDIVIDUAL PARTS.

I. Duplication of limbs—polydactylism, etc.
II. Duplicate mammary glands—polymastia.
III. Supernumerary bones and muscles.
IV. Duplication of viscera.

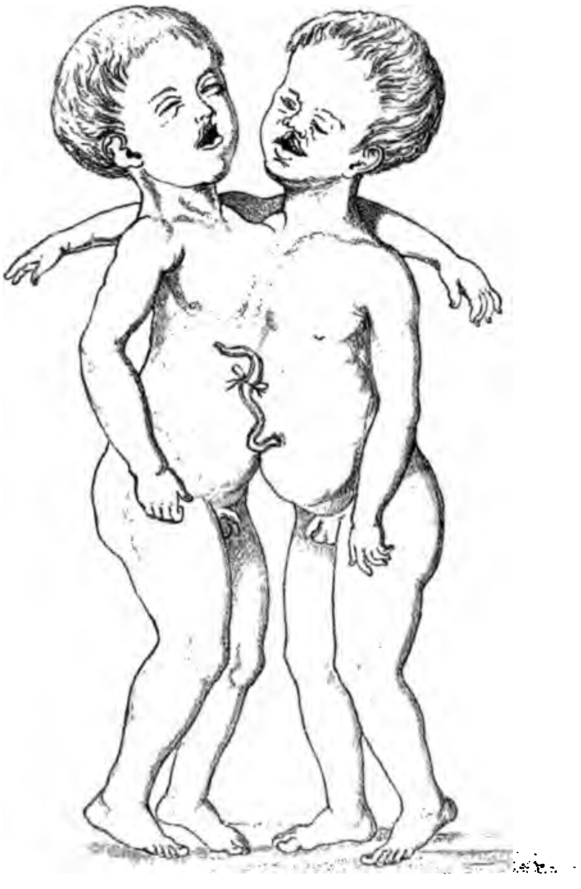


FIG. 565.—THORACOPAGUS.

Thoracopagus.—By this is meant a condition in which the fœtus, completely separated axially, are united by some part of the thorax. In some instances the heads are also confluent, the terms prosopo-thoracopagus, Janiceps, etc., being applied to the deformity. In **Janiceps** (*Janus*, the sun-god) the faces are placed opposite each other. Where the union is by a band opposite the xiphoid cartilage, as in the Siamese twins, the condition is known as a **xiphopagus**; when the sterna represent the point of junction, as a **sternopagus**.

Craniopagus.—Where the twins are bound by the head alone.

Ischiopagus.—Where the axial cleavage is complete, but where the two pelves are fused in a single girdle, the sacra being placed opposite each other.

Acardiacus.—Where the development of the one twin is much below that of the other, and where, among other things, the heart is wanting. In the variety known as *A. amorphus* the autosite is a mere shapeless lump covered by skin, without head, extremities, or genitals. In A. mylacephalus the head end is represented by a hook-like process, smooth or covered with hair. In A. acephalus only the lower part of the body is developed; in A. acormus the opposite condition prevails, namely, fair development of head and face but posterior end wanting.

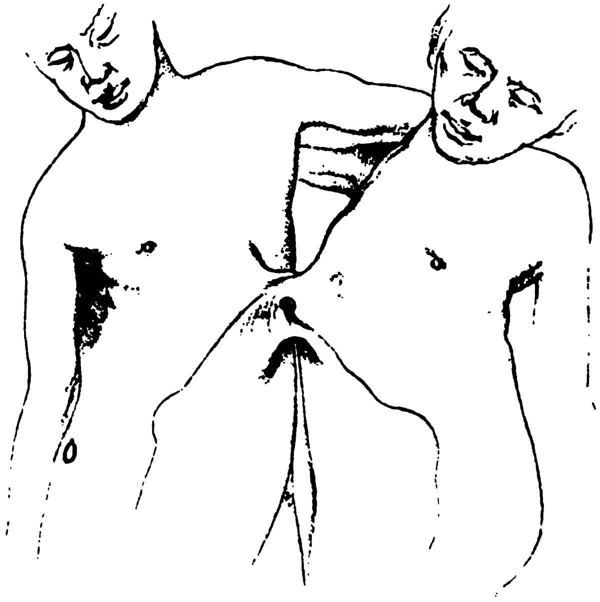


Fig. 566. Xiphopagus.

Thoracopagus Parasiticus.—The autosite hangs as an appendage usually from the neighbourhood of the ensiform cartilage.

Epignathus.—A shapeless lump embedded generally in the lower jaw.

Teratoma.—A mere tumour-like mass made up of simple tissues.

Inclusio Fœtalis.—Where the parasite is hidden in the body of the autosite.

Double pituitary body is the least degree of anterior cleavage.

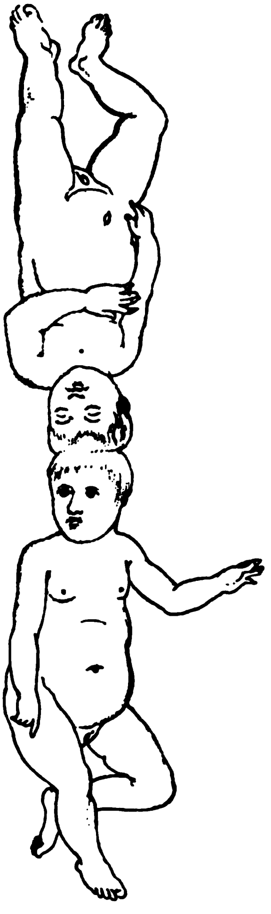


FIG. 567.—CRANIOPAGUS.

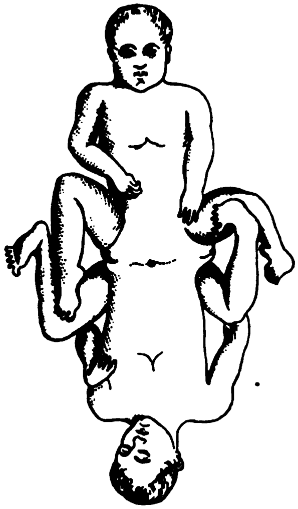


FIG. 568.—ISCHIOPAGUS.

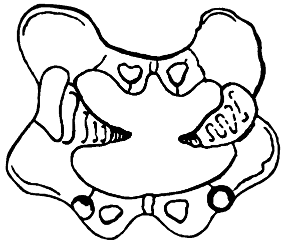


FIG. 569.—PELVIS OF ISCHIOPAGUS.

Dicephalus.—Where the anterior cleavage of the axis goes so far that there are two distinct heads and a single vertebral column. Sometimes the vertebral column is also double for a certain distance downwards.

Pygopagus.—This represents the greatest extent of anterior cleavage. The twins, as in the so-called "Two-headed Nightingale," are united merely by the sacrum or coccyx (Fig. 570).

Dipygus.—By this is understood an amount of posterior cleavage sufficient to furnish a double pelvis.

Tricephalus.—A very rare malformation. The three heads arise from a single rhachis.

Polydactylism.—Multiplication of the fingers or toes is one of the commonest malformations implying cleavage of a part. As before stated, it is often hereditary.

Of all the **viscera** liable to duplication the spleen stands preeminent. A small lymph-gland-like spleen is often met with as an appendage to the main organ.

SITUS TRANSVERSUS.

1095. By this is meant a remarkable malformation in which the position of the viscera on the right and left sides of the body is transposed.

TALIPES (club-foot—*talus*, the ankle; and *pedare*, to foot).

1096. There are four recognised forms of club-foot —namely, T. equinus, T. varus, T. valgus, and T. calcaneus. These varieties are often combined, the most notable being T. equino-varus, T. equino-valgus, T. calcaneo-varus, and T. calcaneo-valgus.

T. Equinus (tip-foot).—The deformity is originally due to a purely musculo-tendinous defect, the tendo-Achillis and muscles of the calf of the leg being the parts at fault. These are contracted in such a manner as to draw the foot upwards, and to cause the individual to walk on the outstretched toes and ball of the foot. In some cases the condition is acquired as a result of infantile paralysis, and in such cases is combined with T. varus.

In course of time, however, the bones become deformed. The astragalus is diminished in size and the articular surfaces are partially deprived of cartilage, while new articular facets form. The articular facet of the astragalus with the scaphoid is unusually small. The calcaneum is forced forwards on the dorsum of the foot. The tarsus comes to lie in a nearly vertical line with the bones of the leg.

T. Varus (*varus*, stretched).—This is the commonest variety of club-foot. The foot is turned inwards and upwards. The heel is drawn more or less upwards, so that the subject of the deformity comes to walk on the outside of the foot. Both feet are as a rule affected, and the deformity is sometimes congenital. The muscles concerned are chiefly the gastrocnemius, with the tibialis anticus and posticus. The bones are altered in such a manner that the astragalus becomes malshapen. The articular surface of the head presents two articular facets; one for the navicular bone, which is displaced inwards and drawn up under the inner malleolus; the other, which can hardly be called an articular facet, projects freely on the back of the foot. It is simply a part of the articular surface of the head left exposed by the shifting of the navicular bone.

T. Valgus (*valgus*, wry or distorted).—The deformity is the opposite of that in the foregoing. The outer border of the foot is directed upwards, the inner downwards, and the sole outwards. The person walks therefore upon the inner aspect of the foot. The muscles at fault are chiefly the peronei, along with, in most cases, some of the extensors of the toes, such as the extensor longus digitorum.

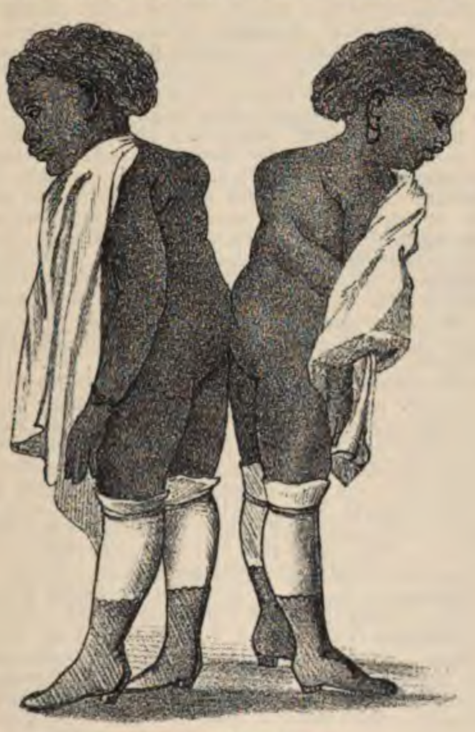


FIG. 570.—PYGOPAGUS.

In flat or splay foot there is very much the same distortion as above described, but in a minor degree, with in addition relaxation of the ligaments of the sole of the foot. It is not usually a congenital affection.

T. Calcaneus (hook-foot).—The toes are drawn up towards the leg, while the heel is markedly depressed. The foot, owing to the depression of the heel, appears to be correspondingly shortened. The calcaneum lies in a line with the leg, and the soft tissues of the heel become hypertrophied.

Literature on Malformations.—**Abercrombie** (Atresia Ventriculi): Trans. Path. Soc., xxxiv. 1882 83, p. 78. **Ahlfeld:** Die Missbildungen d. Menschen, 1880-82, Atlas. **Arnold** (Heart): Arch. f. path. Anat., xlii. 1868, p. 449; *Ibid.*, li. 1870, p. 220. **Ashby** (Atresia Pulm. Art., Stenosis of Tricuspid, Patent Foramen Ovale): Med. Times and Gaz., 1884, i. p. 353. **Beale** (Maternal Impressions): Lancet, 1860, ii. p. 430. **Berridge** (Aortic Valve): Trans. Path. Soc., xxxiv. 1882-83, p. 76. **Bradley** (Heart): Brit. Med. J., Sept. 28, 1872, p. 33. **Bury** (Constriction Pulm. Orifice by Fusion of Valves): Lancet, 1884, ii. p. 183. **Coats** (Aortic Valve): Glasg. Med. J., xv. 1881, p. 372. **Coupland** (Heart): Med. Times and Gaz., 1884, ii. p. 501. **Dareste:** Recherches sur la dualité primitive du cœur, etc., Comptes rend. de l'acad. de sc., lxiii. 1866, p. 608; (Artificial Production) *Ibid.*, lxvi. 1868, p. 155; *Ibid.*, xcv. 1882, p. 254; *Ibid.*, xcvi. 1883, pp. 511, 444; *also*, Recherches sur la production artificielle des monstruosités, 1877. **Dilg** (Heart): Arch. f. path. Anat., xci. 1883, p. 193. **Eichorst** (Bigeminous Heart): Corresp. Bl. f. schweiz. Aerzte, xiv. 1884, p. 369. **Foerster:** Die Missbildungen d. Menschen, 1865. **Fürst** (Lungs): Missbildungen d. Lunge, Handb. d. Kinderkr. (Gerhardt), iii. 1878, p. 553. **Geoffroy St. Hilaire (I.):** Propositions sur la monstruosité, etc., 1829; *also*, Histoire générale et particulière des anomalies de l'organisation, Atlas, 1837. **Greenfield** (Persistence of Left Vena Cava, Absence of Right): Trans. Path. Soc., xxvii. 1876, p. 120. **Hale White** (Diseases of Chorion): Brit. Med. Journ., 1887, i. p. 768. **Heydenreich** (Encephalon Trilobulare and Schistoprosopus): Arch. f. path. Anat., c. 1885, p. 241. **Humphry** (Sp. Bifida): Journ. of Anat. and Physiol., xix. 1884-85, p. 500; *also* (Genu Valgum), Illust. Med. News, vi. 1890, p. 49. **Larcher:** Mélanges de pathologie comparée et de tératologie, 1878. **Marshall** (Development of Great Ant. Veins): Philosoph. Trans., pt. i. 1850. **Maylard** (Lungs): Journ. of Anat. and Physiol., xx. 1885-86, p. 34. **Meyer** (Lungs): Arch. f. path. Anat., xvi. 1859, p. 78. **Müller** (Perforate Ventricular Septum): Arch. f. path. Anat., lxv. 1875, p. 140. **Norman Moore** (Heart): St. Barth. Hosp. Rep., xi. 1875, p. 225; *Ibid.*, xii. 1876, p. 101; Trans. Path. Soc., xxxii. 1881, p. 39. **Orth** (Perforate Septum): Arch. f. path. Anat., lxxxii. 1880, p. 529; *also*, Lehrbuch d. spec. path. Anat., i. 1887, p. 126. **Panum:** Untersuch. über d. Enstehung d. Missbildungen, 1860. **Parker** (Spina Bifida—Report): Brit. Med. Journ., 1885, i. p. 1098. **Peacock:** Malformations of Human Heart, 1866; *also*, Trans. Path. Soc., xx. 1869, pp. 61, 87; *Ibid.*, xxi. 1870, p. 78; xxii. 1871, p. 85; *Ibid.*, xxv. 1874, p. 62; *Ibid.*, xxvii. 1876, p. 31. **Pomer** (Heart): Trans. Path. Soc., xv. 1865, p. 62. **Princeteau:** Progrès de la tératologie depuis Isidore Geoffroy St. Hilaire, Thesis, 1886. **Quain** (Perforate Ventricular Septum): Trans. Path. Soc., i. 1846-48, p. 60. **Reinhard** (Thin Part of Vent. Wall): Arch. f. path. Anat., xii. pp. 129, 143. **Roger** (Perforate Septum): Med.-Chir. Centralbl., xvi. 1881, p. 26. **Rokitansky:** Die Defecte d. Scheidwände d. Herzens, 1875. **Sommerbrodt** (Atresia Aortæ): Deut. mil. ärztl. Ztschr., xii. 1883, p. 55. **Théremin** (Two Cases of Absence of Left Lung): Rev. mens. d. mal. de l'euf., ii. 1884, p. 554. **Tungel** (Double Perforate Septum): Arch. f. path. Anat., xxx. 1864, p. 267. **Turner** (Abnormal Arrangements of Vessels): Brit. and Foreign Med. Chir. Rev., 1862; *also* (Heart, two Cavities), Trans. Path. Soc., xxxiv. 1882-83, p. 32. **Virchow** (Situs Transversus): Arch. f. path. Anat., xxii. 1861, p. 426. **Vulpian** (Artificial Production): Arch. de physiol. norm. et path., iv. 1871-72, p. 90. **Wagstaffe** (Perforate Auricular Septum): Trans. Path. Soc., xix. 1868, p. 96. **White** (Atresia Aortæ): Brit. Med. J., 1884, ii. pp. 826, 909.

CHAPTER XCII

DISEASES OF THE FŒTAL MEMBRANES AND PLACENTA

The Amnion.

1097. **Inflammation.**—It is a thoroughly recognised fact that the fœtal membranes may become inflamed *in utero.* The amnion sometimes shows evidence of this in the production of adhesions between the membrane and some part of the fœtus. These adhesions are commonest at the head-fold, and are said to account for many of the deformities found in connection with the vault of the skull and enclosed viscera (p. 92).

Hydramnion.—By this is understood an excessive accumulation of amniotic liquid. It is usually regarded as expressive of obstruction to the flow of the maternal circulation. It has been suggested that the accumulated liquid is in part fœtal urine, but this seems unlikely. The placenta is usually enlarged in these cases, and the choroidal villi swollen and apparently dropsical. The fœtus is either dead or under-developed. Actual deformities in the fœtus have been alleged to be traceable to this cause, but the evidence in support of the allegation seems meagre.

Deficient Amniotic Liquid.—When the amniotic liquid is scanty the undistended membranes press upon the enclosed fœtus. This pressure must be ranked as a frequent cause of malformation. It is quite likely that many defects in the development of the head and limbs are caused in this way.

Chorion and Placenta.

1098. When the fœtus dies at an early stage the chorion need not be discharged. The ovum in most cases disappears; it is most likely absorbed. The choroidal villi and placenta degenerate, and possibly this degeneration accounts for the death of the embryo. The chorion, however, does not necessarily die. It continues to grow, although the growth often shows a morbid type. The resulting structure still goes by the old-fashioned name of a **mole** (*mola*, a false conception).

There are chiefly two varieties of these structures—the so-called *fleshy mole* and the *hydatid mole.*

Fleshy Mole.—This takes the form of a cast of the interior of the uterus, and may be expelled in an unruptured condition. It possesses a large cavity in which fœtal remains often cannot be detected. Its walls may be from a quarter to half an inch thick or even more, and in general consistence it resembles a placenta. Hæmorrhages of considerable bulk may be detected in it, and here and there cysts filled with clear liquid, and from the size of a pea to that of a walnut, project into its interior. It looks almost as if the whole chorion had undergone placental thickening, while some of the villi had suffered from cystic degeneration.

Hydatid Mole.—In this case the appearances of the ejected chorion are different. There is not the same fleshy thickening of the membrane. The whole of the placental and choroidal villi seem to have been transformed into grape-like bunches of rounded cysts. These cysts vary in size. The smallest are almost microscopic; the largest perhaps come up to the size of a large pea. They are filled with clear fluid, which is said to contain mucin (Fig. 571).

The view has been entertained that the connective tissue corpuscles of the choroidal villi are the source of the cysts—that they become distended and stretched with a dropsical liquid. A more feasible explanation is that parts of the villi suffer from mxyomatous degeneration and that the cyst-like bodies are points where the resulting mucoid has accumulated.

Sometimes only certain cotyledons are affected, and then the child may live up to full time.

Fatty Degeneration of the Placenta.—It has been supposed that a fatty degeneration of the placental villi takes place naturally at the full limit of utero-gestation. Such does not seem to be the case. The great bulk of placentæ at full time do not show any such appearance. There is no commoner alteration of the placenta than a fatty condition of its villi. The seat of the degeneration is usually said to be the blood-vessels. The oil globules, however, are far more often found on the surface of the villus than in its interior where the vessels lie. The particular structure affected appears to be the layer of epithelium covering the surface, and separating the fœtal from the maternal parts—the remains of the sub-zonal membrane. Any fatty change in this structure would, from the important position it holds, and from the probable function it subserves, tend to interfere with the whole economy of the placenta.

White Infarcts.—Pale yellow masses of tissue are often found scattered throughout the substance of the placenta. They have been called **white infarcts** by Hoffmann; and have been held to be indicative of a syphilitic infection. They have also been found associated with large and pale kidneys (Favre, No. 13, cxx. 1890, p. 461). If they are not extensive, utero-gestation may go on to full time.

They are of various shapes and sizes, the smallest about the size of a hemp-seed, the largest coming up to that of a walnut. They are often wedge-shaped, and are best seen upon the attached aspect of the placenta. Spaeth and Wedl (quoted by Ackermann, No. 13, xcvi. 1884, p. 439) found them in 3½ per cent of all placentæ.

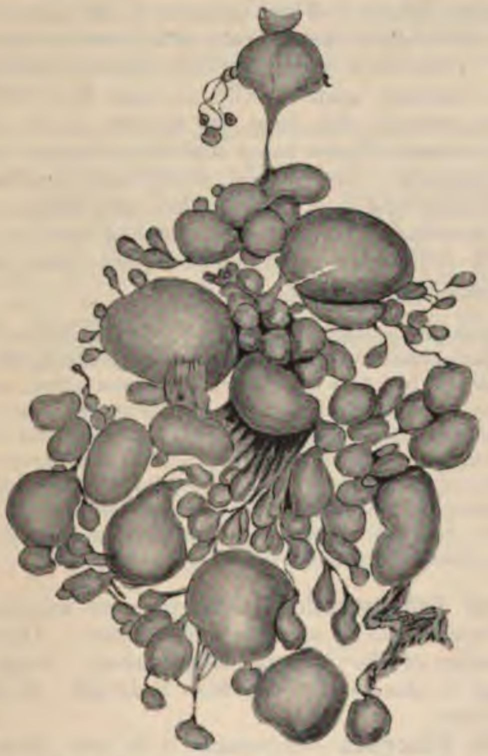


FIG. 571.—HYDATID MOLE SHOWING THE BLADDER-LIKE CYSTS ATTACHED TO A STEM.

Examined microscopically, they consist in great part of masses of fibrin. The fibrin is homogeneous as in an aneurismal sac, not in the form of a network, and has canal-like spaces and fissures coursing through it.

It surrounds and fixes, embeds in fact, the placental villi. The artery and vein, or the artery alone, are said by Ackermann to be embedded in a small-cell (inflammatory) deposit; but this has not been confirmed by others. The epithelium covering the villi desquamates, assumes a homogeneous appearance, and vanishes in the surrounding fibrin.

All sorts of theories have from time to time been invented to account for these deposits. They have been supposed to be inflammatory (Simpson), to be caused by hæmorrhage (Gierse), or to be masses of placenta in a state of coagulative necrosis as in yellow infarction of the kidney and spleen (Ackermann).

Summarising the facts derived from recent observation by various writers (see Bibliog.), the course of events in their formation seems to be somewhat as follows:—There appears in all cases to be a dense accumulation of serotina-like decidual cells between the maternal and fœtal parts. These cells are most likely derived from the serotina. They come to impinge upon the villi, to force their way beneath its epithelium, to separate this from the surface of the villus, and to envelop the stroma. There being now no structure separating the villi and the maternal blood-vessels, blood-plasma is effused either in the form of a hæmorrhage or as an exudate, and coagulates. A great many of the serotinal cells seem to become homogeneous, to mix with this, and thus to disappear; and, as before mentioned, the epithelium of the villi meets a similar fate.

Both Rossier and Favre state that, along with these occurrences in the placenta itself, an obliterative affection of the uterine arteries opposite the affected part takes place. It is brought about by a thickening of the tunica intima, and apparently is quite homologous with that which occurs in the uterine arteries generally after parturition. What is not quite clear, however, and this is just the turning point in accounting for this curious lesion, is whether the state of the arteries is primary or secondary to that of the placenta. In cases which are syphilitic it might be supposed to be primary, but, on the other hand, it might be argued that the condition of the arteries is simply one of premature involution, owing to the corresponding cotyledon of the placenta having died or become functionally inert.

Placental Inflammation.—The placenta sometimes becomes fixed to the uterine wall by adhesive inflammation. This is a common cause of a portion of the placenta being retained. *Suppurative inflammation* ending in abscess has also been recorded. It is, however, a very rare affection.

Syphilitic Placenta.—Gummata, it is said, have been found within the placenta. The white infarcts just described may be readily mistaken for them.

TUBERCULAR INFECTION OF FŒTUS IN UTERO.

1099. It is a well-known fact that the tubercularisation of the fœtus *in utero* is among the rarest of occurrences. Only a very few records of such having taken place are to be found in medical literature, and in some of them it seems probable at least that the deposits called tubercular were in reality syphilitic. Even in extreme general tuberculosis of the mother, the fœtus, placenta, and membranes in the vast majority of cases are free from any tubercular deposit and from the presence of the tubercle bacillus.

Curt Jani (No. 13, ciii. 1886, p. 522) attempted to account for those few cases in which intra-uterine tuberculosis has been alleged to have been found, by a tubercular infection of the ovum through the sperm of the male or the Fallopian tube of the female. He said that he found tubercle bacilli in the prostate and Fallopian tubes in cases of general tuberculosis, even where these were otherwise free from disease. It may legitimately be asked, however, what tubercular infection of the ovum means. Landouzy and Martin asserted that they had rendered guinea-pigs tubercular by injecting into them the semen of tubercular rabbits. Rohlff, however, has failed to induce tuberculosis by injecting the semen of tubercular men into the anterior chamber of animals.

Literature on Diseases of Fœtal Membranes and Placenta.—**Ackermann** (White Infarct.): Arch. f. path. Anat., xcvi. 1884, p. 439. **Hoffmann**: Ueb. d. weissen Infarct. d. Placenta, 1882. **Küstner** (White Infarct.): Arch. f. path. Anat., cvi. 1886, p. 342. **Langhans**: Arch. f. Anat. u. Entwickelungsgesch. v. His u. Braune, 1877, p. 214; *also*, Arch. f. Gyn., i. p. 330, and iii. p. 150. **Maier**: Arch. f. path. Anat., xlv. 1869, p. 305. **Oberdieck**: Ist d. Placenta durchgängig f. Mikro-organismen, 1888. **Priestly-Smith** (Cystic Chorion): Brit. Med. Journ., 1887, i. p. 768. **Robin**: Arch. gén. de méd., i. 1854, p. 705. **Rohr** (White Infarct.): Arch. f. path. Anat., cxv. 1889, p. 505. **Rossier** (White Infarct.): Basler Dissertation, 1888. **Simpson**: Edin. Med. Journ., April 1836, p. 265. **Spaeth and Wedl**: Klinik d. Geburtshülfe u. Gynaekol v. Chiari, Braun and Spaeth, Erlangen, 1855, p. 101. **Winkler**: Structure u. Zell-leben in d. Adnexen d. mensch. Eies. Jena, 1870.

PART IV

DISEASES DUE TO VEGETABLE AND ANIMAL PARASITES

CHAPTER XCIII

A. SYSTEMATIC BACTERIOLOGY

Introductory.

1100. THE general methods pursued in bacteriological research have already been indicated (vol. i. p. 112). And where diseases caused by a vegetable parasite have been described, most of the particulars concerning the parasite have been included in the description. It now remains to treat of the subject of Bacteriology from a systematic point of view, and to describe those parasites and their effects which do not influence any organ in particular, but which give rise to a disease affecting the system more or less generally. Such are the organisms of anthrax, septicæmia, etc.

From the fact that the living animal body is such a rich storehouse of those very substances which serve as their natural food when leading a saprophytic existence, it is not surprising that certain microphytes have become parasitic. Indeed the marvel is that the living organism resists their invasion so well as we know it does.

Plants, although they sometimes become a prey to parasitic microbes, are not so liable to disease from this cause as animals. It is said that their juices and tissues do not furnish so favourable a pabulum as the corresponding juices and tissues in animals. Their acid reaction is said to render them proof against many varieties.

Conditions of Existence of Bacterial Life.

1101. In studying the low forms of vegetable life which are parasitical on Man and animals, attention must be paid more particularly to their morphology, life history, and properties of assimilation and metabolism—to their physiology, so to speak—and to the various effects which they themselves or the products secreted or otherwise elaborated by them have upon individual tissues and upon the system generally.

According to their habits they are divided into two classes, *saprophytes* and *parasites.* The saprophytes are such as grow on dead organic substances, the parasites those which lead an existence upon a living host. Some, but only a few, are pure parasites—that is to say, their existence as saprophytes is unknown. They are distinguished as *obligatory parasites* (parasites obligés). Many supposed members of this class have lately been shown to be capable of artificial cultivation. The leprosy bacillus, however, so far as we know, refuses to grow on anything but the living animal body. This difficulty, it is only reasonable to believe, will ultimately be overcome. And so it is with others. Their number is rapidly diminishing in consequence of the discovery of the particular conditions necessary for their flourishing in a saprophytic condition.

Most of the parasitic microbes, it may now be asserted, can be made to lead a double existence, namely, that of saprophyte and parasite. To such the term *facultative parasites* (parasites facultatifs) is usually given.

Certain moulds which in their natural state are exclusively saprophytic can be made to lead a parasitic life when transferred artificially to properly constituted animal hosts. Hence, even in the case of the purely obligatory members, those which apparently will grow only on the living animal body, there is the presumption that, at some time, they have been saprophytic, and that their parasitic qualities have been acquired by long custom. The tendency, however, is greater in the opposite direction. Many of the parasites can be readily induced to take on, shall we say, to revert to, a saprophytic habit.

The terms *saprophytic* and *parasitic*, accordingly, are nowadays employed but slenderly ; those of *pathogenic* and *non-pathogenic* are in much commoner use.

Classification of the Parasitical Mycetes.

1102. That which perhaps has met with most favour was proposed by Nägeli (No. 586), namely, into—

(1) The moulds or hyphomycetes ;

(2) The yeasts, sprouting fungi, or blastomycetes ; and

(3) The cleft fungi or schizomycetes.

The general opinion is that they may all be comprised under the fungi or mycetes. de Bary, however, does not include the bacteria among the fungi, but believes that they are more nearly related to them than to any other group. He prefers to designate them bacteria rather than fission-fungi. Indeed the fission-fungi have been variously designated, and many of the terms are still in common use. Thus that of *microbe* was given to them by Sédilot, *microzyme* by Béchamp, *microbe* by Pasteur, and in this country, that of *bacterium* is often applied to the group in a generic sense. They were relegated to a separate class, the *protista*, by Haeckel.

Zopf (No. 587) further divides the schizomycetes into the following groups and genera :—

	Genera.
1. *Coccaceæ.*—Up to the present time, known only in the form of cocci.	Streptococcus Merismopedia Sarcina. Micrococcus Ascococcus.
2. *Bacteriaceæ.*—Have for the most part spherical, rod-like, and filamentous forms ; the first (cocci) may be wanting; the last are not different at the two extremities ; filaments straight or spiral.	Bacterium Spirillum Vibrio Leuconostoc Bacillus Clostridium.
3. *Leptotricheæ.*—Spherical, rod-shaped, and filamentous forms ; the last show a difference between the two extremities ; filaments straight or spiral ; spore formation not known.	Crenothrix Beggiatoa Phragmidiothrix Leptothrix.
4. *Chadotricheæ.*—Spherical, rod-shaped, filamentous, and spiral forms ; the filamentous form presents pseudo-branches ; spore formation not known.	Cladothrix.

This classification of Zopf's, however, it must be remembered, is founded upon the doctrine of **pleomorphism**—that is to say, on the supposition that an organism may take on different forms according to its surroundings. Thus the usual form assumed by the bacillus pyocyaneus is that of a short rod. By simply modifying the basis on which it grows, however, Charrin (No. 641) finds that it may assume successively the character of a coccus, a long thread, or a spirillum. The transformations of proteus (Sect. 1119) are another example of the same. It should not be forgotten, however, that the possibility of an organism assuming such a multiplicity of shapes is opposed by some competent authorities.

Their General Characters.

1103. The features which are peculiar to the fungi as distinguished from all other forms of vegetable life, are that they are devoid of stem and leaves, and are composed of elongated cells or rows of these united in threads. They possess no trace of chlorophyll, and on this account it has been supposed that they fail to build up organic compounds from unorganised raw material. As explained under *Nitrification*, however, this supposition has had to be modified in view of evidence recently acquired.

Chemical Actions performed by them.

1104. The chemical interchanges brought about by living organisms are of two kinds: (1) *Synthetical*, accomplished chiefly by plants ; (2) *Analytical*, performed mainly by animals. The class of

Mycetes, however, which we are now considering is also largely analytical, and hence stands intermediate between the two. Some of them excite *fermentation*, others *putrefaction*. The ferments are almost alike with those secreted by the peptic and other digestive glands, and have the property, consequently, of peptonising and liquefying culture media containing gelatine. In a large proportion of cases a *poisonous alkaloid* is the most important product, while in a certain number a *poisonous albumose* is either associated with this, or is secreted separately. A few of them evolve gas from the basis on which they are grown. In some cases a foul-smelling volatile substance is the most notable (Bacillus saprogenes).

Briefly summarised, the products evolved are chiefly as follows :—

(1) *Gases* (carbonic acid, hydrogen, light carburetted hydrogen, sulphuretted hydrogen, and ammonia).

(2) Nitrates, water, and sulphur.

(3) Volatile substances (trimethylamin, alcohol, formic acid, acetic acid, propionic acid, butyric acid).

(4) Fixed acids (lactic, malic, succinic, oxalic, and tartaric).

(5) Taurin, leucin, alanin.

(6) Bodies belonging to the aromatic series (tyrosin, phenol, and kresol).

(7) Bodies of complicated molecule (carbohydrates, albumoses, peptone, hydrolytic ferments).

(8) Colouring matters.

(9) Alkaloidal poisons (ptomaïnes).

I. THE MOULDS OR HYPHOMYCETES.

1105. **Morphology.**—They are composed of two distinct parts, the *mycelium* and the *fruit-bearing organs*. The mycelium consists of a tangled mass of delicate threads made up of elongated jointed cells. It ramifies deeply within the basis from which the mould is growing. In one type of mould, of which **Penicillium glaucum** is a good example, the fruit-bearing organs spring from aerial stems or *hyphæ*, also composed of rows of jointed cells, terminating in a brush-like bunch of branches known as *basidia*. From these basidia finer secondary branches are given off known as *sterygmata*. The conidia, or, as they are called, the conidial spores, are placed on the ends of these sterygmata. The bluish-green colour which the surface of this mould presents is due to the coloration of the conidia.

In **Aspergillus glaucus** very much the same arrangement prevails, only the fruit-bearing branches are not secondarily divided. The bottle-shaped sterygmata are arranged radial-wise in a single layer, and possess only one large spore, which is placed at the end.

Mucor mucedo flourishes on animal excrement, fruit, etc., particularly well on horse-dung. It is the cause of the ordinary white growth on such bodies. It develops thick white masses of mycelial threads, from which spring the fruit-bearing hyphæ, *conidiophores* or *sporangiophores*. A button-like extremity (columella) shows in time at the end of each of the hyphæ. Around it forms the sporangium, composed of a membrane (epicarp) enclosing protoplasm. The protoplasm divides into spores or conidia, and these again are set free by rupture of the sporangium.

Oidium grows in simpler fashion than these other moulds. The *oidium lactis* is the white mould of milk. It is devoid of fruit heads. The conidia spring up in long strings directly from the mycelium.

Chemical Composition.—Their chief characteristic in this respect is that the non-nitrogenous organic elements (cellulose) exceed the nitrogenous. Proteid constituents are found only in the cell contents. They contain sugar-like bodies, and the salts are composed chiefly of potassium and phosphoric acid.

Conditions of Growth.—They increase and flourish where there is comparatively little moisture. It is not so with the yeasts; they require a plenteous supply of water. As regards the inorganic materials necessary for the maintenance of the moulds, they appear to be twofold, namely, a salt of an alkali (potassic phosphate) and of an alkaline earth (earthy phosphate). Free oxygen is also necessary, and the medium had best have an acid reaction.

Their nitrogen is assimilated most readily from soluble proteids and peptones, but, contrary to what was at one time supposed, it can also be taken from nitrates and ammonia salts. Their supply of carbon is best obtained from easily-split-up carbohydrates such as sugar; the sulphur from sulphates and sulphites. Several culture media suited for their growth, such as Pasteur's and Cohn's fluids (vol. i. p. 113), have been prepared by combining the constituents necessary for their nourishment synthetically.

Cultures of moulds differ from those of bacteria in the fact that they tend to become inextricably mingled. The mycelium of the one becomes intertwined with that of the other. An impure growth, moreover, is less easily detected than in the case of bacteria, from the fact that two or more may be growing together without loss of homogeneity. Cultures of trichophyton tonsurans, for instance, are almost always impure.

According to Sabouraud (No. 423, vii. 1893, p. 516), those which are parasitical can best be isolated pure by the use of must of beer. They grow readily upon this, but the parasitical cryptograms do not. So soon as the culture has reached maturity upon this it should be transferred to the surface of potato. This medium, like a gelatine surface, has the property of isolating the one organism from the other, so that after a few successive transferences a mould like the trichophyton can be obtained perfectly pure.

Mould colonies growing on a gelatine surface side by side with yeasts, sarcinæ, bacteria, etc., can be readily distinguished by the radial manner in which the mycelium spreads out from a common centre, and by the rapidity with which they overspread the medium. A needle track upon the surface soon begins to throw out branches which give to the margin of the growth a characteristically fringed appearance (Fig. 503).

Question of Saprophytic Moulds becoming Parasitic.—Besides those which lead mainly a parasitic existence in the skin (see Skin Diseases), there are others which, as a rule, are saprophytes, but which may also occasionally become parasitical. These are generally held to be Aspergillus fumigatus, Aspergillus flavescens, Mucor rhizopodiformis, and Mucor corymbifer. Among the common moulds which are not usually parasitic may be mentioned Penicillium glaucum, Aspergillus glaucus, Aspergillus niger, Mucor mucedo, Mucor stolonifer.

A pneumomycosis aspergillina has been described by various observers, such as Virchow, Friedreich, Pagenstecher, and Fürbinger (see Bibliog.). Aspergillus has also been found growing within the ear (Bezold) and upon the cornea (Leber). In the most of these cases aspergillus fumigatus has been the species; but A. flavescens or a black aspergillus has also been met with in the ear. The latter of these two has also been detected in the lung. The moulds in question lead not only a saprophytic existence, but also one which is parasitic upon the animal body. They are found in the blood-vessels of various organs, and, in the kidney, block up the capillaries of the glomeruli.

Lindt (No. 104, xxi. 1886, p. 269) has discovered that two species of mucor may also become parasitic, and fructify within the blood-vessels. He calls them Mucor pusillus and Mucor ramosus. Schütz (No. 44, ii. 1884, p. 208) found that the inhalation of aspergillus spores induced a pneumomycosis aspergillina. Grohe (No. 43, vii. 1870, p. 8) has induced a fatal disease by injecting mould spores into the circulation. Grawitz, however (No. 13, lxx. 1877, p. 546), obtained results at variance with these in the fact that, after as many as two hundred experiments, made by injecting spores of Aspergillus glaucus, Penicillium glaucum, Mucor mucedo and stolonifer, and other moulds into the blood-vessels, subcutaneous tissues, etc., in not a single case could he say that he had excited anything like a diseased condition by the procedure. It is possible that the quantity injected may have been too small. He says that the spores are partly destroyed in the circulating blood, partly eliminated by the kidneys.

Leber (No. 647) has shown that aspergillus and penicillium when inoculated on the cornea may grow and spread from the original focus. They may be the cause of inflammation of its structure.

Literature on Mould Fungi—Saprophytic Moulds as Parasites.—**Bezold**: Ueber Otomycosis, 1881. **Bristowe** (in a Cavity): Trans. Path. Soc., v. 1853-54, p. 38. **Cohnheim**: Arch. f. path. Anat., xxxiii. 1865, p. 157. **Delépine**: Tr. VII. Internat. Cong. Hyg. and Demog., 1892, ii. p. 107. **v. Dusch and Pagenstecher**: Arch. f. path. Anat., xi. 1856, p. 561. **Friedreich**: Arch. f. path. Anat., x. 1856, p. 510. **Fürbinger**: Arch. f. path. Anat., lxvi. 1876, p. 330. **Heimer**: Ueb. Pneumonomycosis Sarcinica, 1877. **Israel**: Centralbl. f. d. med. Wissensch., xxiv. 1886, p. 306. **Leber** (on Cornea): Arch. f. Ophthal., xxv. 2 Heft, p. 285; *also*, Berl. klin. Wochnschr., xi. 1882, p. 160. **Manson** (Tinea Imbricata): Brit. J. Dermatol., iv.

1892, p. 5. **Nauwerck** (Pneumonomycosis and Pharyngomycosis sarcinica): Cor. Bl. f. schweiz. Aerzte, xi. 1881, p. 225. **Paltauf**: Arch. f. path. Anat., cii. 1885, p. 543. **Rother** (Pneumomycosis Aspergillina): Charité Ann., iv. 1877, p. 272. **Schutz**: Mitth. a. d. k. Gesundheitsamte, ii. 1884, p. 208. **Stieda** (Pneumomycosis Aspergillina): Arch. f. path. Anat., xxxvi. 1866, p. 279. **Virchow**: Arch. f. path. Anat., ix. 1856, p. 557.

II. THE YEASTS, SPROUTING FUNGI, OR BLASTOMYCETES.

1106. These consist of round or ovoid cells of various sizes, composed of a mass of protoplasm enclosed in a capsule. The cell protoplasm is granular and often vacuolated (Fig. 572). Increase in number takes place by budding or gemmation and abstriction. A little bud forms on one side of the parent cell. This increases in bulk, and becoming constricted at its point of attachment, finally separates.

Although this is the usual mode of reproduction, it has been shown by Rees and Hansen that yeasts may develop spores. At other times a long unsegmented filament may show itself, and even, it is said, a chain or budding mycelium. A dilute culture basis favours the formation of filaments, a culture liquid rich in sugar predisposes to division by budding.

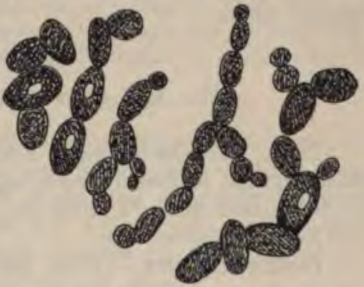


FIG. 572.—TORULA CEREVISIAE (BEER YEAST).

The clear spaces in the centres of some of the yeast particles are vacuoles ($\frac{1}{12}$ homog. imm. Crouch, Hartk., Oc. No. 3; stained with gentian-violet).

Composition. — According to M'Fadyean (No. 161, 1889, p. 485), they contain 37 per cent cellulose and 47 per cent proteid matter. As regards relative quantity, these two constituents are in inverse proportion as compared with the moulds (50 per cent cellulose and 29 per cent proteid). They also contain relatively more phosphoric acid. The amount of water comes up to from 40 to 80 per cent. A peculiar proteid substance common to the yeasts and the schizomycetes enters pretty largely into their composition. It is known as mycoprotein (Nencki—see p. 965).

Nourishment.—The conditions of nitro-assimilation are much the same as in the case of the moulds. They undergo degeneration after a time if nourished solely upon ammonia salts. Nitrates are not reduced by them. They derive their carbon from the same sources as the moulds; sugar-like carbohydrates are most suitable. Some of them require special carbon compounds, as, for instance, alcohol in the case of the mycoderma vini. The mineral foods are potassium and calcium in combination with phosphoric acid.

Conditions of Growth.—They can grow without the presence of free oxygen if a fermentable body be present. Excess of alkalinity or of acidity hinders their growth. The best range of temperature is from 10° to 40° C., the optimum temperature is from 25° to 30° C. Their growth is so vigorous that they will starve and outgrow any bacteria living on the same culture basis provided they are permitted to exercise their fermenting function.

Fermenting Function.—The yeasts are the active agents in alcoholic fermentation. This function appears to be something apart from that of the ordinary metabolism which goes on within them. As the organism continues to multiply in a solution of grape sugar, alcohol, carbonic acid, and many by-products are developed.

Those yeasts which split up the sugar molecule are called *saccharomyces* (*μύκης*, a fungus). Of these the more important are (1) *S. cerevisiæ* (torula cerevisiæ), the ordinary beer fungus; (2) *S. vini*, that of grape juice; (3) *S. pastorianus*, that of cider. Hansen has isolated several others.

III. The Cleft-fungi or Schizomycetes.

1107. The characteristic and distinctive feature of this group of bodies is that of their reproducing themselves by cleavage. They may at times, and most of them do, reproduce themselves by spores, but this method is uncertain.

Nomenclature.—When the body in question is about 1 μ in length, it is usually known as a **microbacterium** (*βακτήριον*, a rod), and if it is round or rounded in form, the term **coccus** (*κόκκος*, a kernel) is applied to it. Should the organism be elongated, and should the length be about double the breadth, it is termed a **bacillus** (*bacillus*, a small stick, from *baculus*). Sometimes a rod may contain a spore at its centre. The centre of the rod consequently is swollen, so that the organism assumes a spindle or lemon shape. To this form the term **clostridium** is applied. Long unjointed threads are known as **leptothrix.** When these long threads branch, and when the branching is caused by an axial splitting of the terminal cell, **cladothrix** is the term used. The term **spirillum** is applied generically to curved rods or filaments, rigid or flexible, and developing by endogenous spores. A long thread thrown into gentle undulations, and with sinuous movements, is known as **vibrio.** If the curves are slight and the thread very thin with rotatory movement, the organism is generally known as **spirochaeta.** When splitting occurs in two directions, so that a group of four members or tetrads results, the term **merismopedia** is applied to the group, but when the splitting occurs in three directions, and packets of eight or more members are formed, that of **sarcina** or "wool-pack form." Colonies are sometimes held together by a little cementing substance; they are known as zooglœa.

Structure.—Speaking generally, the schizomycetes are composed of proteid matter enclosed in a membrane. This enclosed proteid is sometimes called the protoplasm. Outside, there is a limiting capsule or sheath. It is the protoplasm which stains with aniline dyes. Between the sheath and the protoplasm, in stained preparations, there shows a clear area. It appears to be occasionally the effect of reagents, at other times to be a layer of protoplasm different from that in the interior. Outside the sheath, again, there is often a gelatinous glia. In capsule cocci this is largely developed, and in leuconostoc so prolific is it that it confers upon the colony a frog's-spawn-like gelatinous consistence. Such a glia also serves to bind aggregations of cocci into the so-called **zoogl&oelig;a masses.** The membrane in sarcina ventriculi has the qualities of a typical plant cellulose. It is firm and thin, and gives a violet reaction when treated with Schulze's solution.[1]

The species Beggiatoa (allied to Crenothrix and Cladothrix) is said to have the power of reducing sulphates contained in water, and of setting free the sulphur and sulphuretted hydrogen. Sulphur grains, accordingly, are deposited in the protoplasm. Iron is also precipitated by the sulphuretted hydrogen, hence the organism may be blackened.

The substance of bacteria resembles that of other cells in composition. It is made up of albuminoid compounds such as *mycoprotein.* Mycoprotein or fungus-protein is an albuminoid substance described by Nencki (No. 626, xx. p. 443; *also*, No. 627, p. 35), which enters largely into the composition of their membranes and protoplasm. Their limiting membrane is said also to contain fat.

The amount of cellulose which enters into their structure is even lower than in the case of the yeasts. The ash has probably the same composition as that of the yeasts.

Nourishment.—It used to be supposed that, as the fungi are achlorophyllous, they are incapable of building up their structure from elements contained in other than organised substances. It was held that they could not abstract their carbon from carbonic acid nor their nitrogen from ammonia or the nitrogen of the atmosphere. They were held to break up dead organic substances of a vegetable or animal nature, and to reduce them to simpler compounds. There was thus drawn a sharp line of demarcation between them and the algæ, bodies which contain chlorophyll. And, although they certainly do assimilate their nitrogen best from albuminous matters and their carbon say from the easily-broken-up carbohydrates, yet such a hard-and-fast line of separation as that formerly suggested cannot now be entertained in view of recently-acquired knowledge.

Thus Pasteur has shown that torulæ are able to assimilate C. and N. from some inorganic bodies such as ammonia salts, and Hueppe

---

[1] Zinc is dissolved in hydrochloric acid, and the solution allowed to evaporate in contact with metallic zinc until it assumes a syrupy consistence. The syrup is then saturated with potassic iodide, iodine is added, and the solution when necessary is diluted with water.

(No. 639) has demonstrated that a bacterium without chlorophyll can acquire its C. from carbonic acid, or even from carbolic and salicylic acids when dilute. Some of them, moreover, can reduce nitrates, and others oxidise ammonia to nitric acid (Heraeus). The same organism is said (Hueppe) to possess sometimes both reducing and oxidising properties.

Microbes, apparently, can adapt themselves in a wonderful manner to circumstances. They can abstract their nourishment when compelled to do so from unorganised substances, and they can turn out products varying in composition according to the character of the extraneous conditions. Wherever, moreover, they secrete a ferment their powers of assimilation are much enhanced.

A still more remarkable property possessed by certain of them is that of taking up free nitrogen from the atmosphere. An account of the facts bearing upon this is given under *Nitrification*.

As Frankland remarks (No. 636, xlvi. 1892, p. 138), there is a discriminativeness in the manner in which bacteria attack a particular culture basis which is difficult to understand. Thus mannite and dulcite closely resemble each other in physical properties, and as far as ascertained their chemical composition is identical. Yet ordinary yeast refuses to attack either of them. Some organisms attack the one or other, while others attack both.

Certain of the cleft-fungi require a free supply of oxygen; they are called **aerobes.** Others fail to grow where oxygen is present, and are known as **anaerobes.** While some lead both an aerobic and an anaerobic existence. Liborius (No. 366, i.) divides them consequently into three groups, namely—

1. Obligatory anaerobes, which reach their optimum growth only in absence of free oxygen, *e.g.* Bac. butyricus and the Bac. of malignant œdema.

2. Facultative anaerobes, which grow best with free oxygen, but continue to live and multiply in absence of it. Such are many pathological microbes, as, for instance, Koch's comma bacillus.

3. Obligatory aerobes, which do not grow in absence of oxygen, such as Bac. subtilis.

Some of these are parasitic, some saprophytic. A third contingent is both parasitic and saprophytic.

Albumin seems to be the material upon which the group of Schizomycetes lives and flourishes best, either in its raw state, as in white of egg, or, what is more suitable, in the form of peptone. The culture media most in use at the present day are largely composed of peptone. The necessary salts are superadded.

The addition of a small quantity of *glycerine*, as discovered by Roux, has a remarkable effect in facilitating the growth of some varieties. The tubercle bacillus, for instance, fails to grow on ordinary agar-peptone, but the addition of from 5 to 6 per cent of glycerine converts the medium into one excellently suited for the purpose.

Their Reproduction.

1108. As before stated, all the schizomycetes reproduce by fission. The majority of them also multiply by sporing. The determining cause of the one or the other method appears to be the richness or poorness of the soil upon which they are grown. If particularly rich, then they multiply almost exclusively by fission; if poor, it may be that they increase to some extent by fission, but more so by sporing. Anthrax, for instance, growing upon the rich albuminous basis afforded by the living blood reproduces itself exclusively by fission. Sown on potato, however, which affords a less nutritive pabulum, it increases mostly by formation of spores.

Reproduction by Fission.—When a rod-shaped organism has reached its extreme length a partition appears in the centre. This assumes a homogeneous or gelatinous character and a line of cleavage shows itself in the midst of the partition. A complete separation into two new organisms follows. In the case of a round organism, such as a coccus, elongation takes place so that the body becomes ellipsoidal in shape, or may for the time being assume the character of a short cylinder with round extremities. A constriction shows itself at the middle, which deepens and finally separates the single body into two individuals. The resulting parts are sometimes unsymmetrical. Division of cocci sometimes takes place in two directions (micrococcus tetragenus), the tetrads being held together by a little cementing substance. In sarcina the division follows three directions, the result being a cube of sixteen members.

Reproduction by Spores.—By a spore is meant a body which can develop into a series of new generation forms. A coccus is not a spore, because it invariably remains as a coccus; it does not proceed to anything further. The spore is always the commencement of the series.

They are of two kinds, **endogenous spores** and **arthrospores** (de Bary, No. 589, p. 22). Endogenous spores are developed within parent cells. A little clear point, say in the case of anthrax, appears in the protoplasm of the parent cell. This becomes more defined, and a capsule forms round about it. It is supposed by Koch that the spore of anthrax is constituted of a fat droplet surrounded by a protoplasmic envelope and by a resistant membrane. The fat droplet confers powers of resistance and serves for nutrition during germination. It renders the spore highly refractile. The membrane is sometimes double. The protoplasm of the cell disappears, being consumed probably for the benefit of the spore. It seems likely that only one spore forms in each member, say in a chain of anthrax segments. The thinness of the partitions between the segments, or their disappearance, makes it appear sometimes as if there were continuous chaplets of spores. The spores are ultimately set free by the gelatinising of the septa.

Arthrospores are formed in the following manner:—One of the best examples, and the one which is generally quoted, is at the instance of Leuconostoc, the frog-spawn-like fungus which grows on the side of sugar vats in sugar factories. So rapidly does it develop that, in a single night, it may spread through and destroy an entire vat of sugar.

Examined microscopically, it is found to be composed of colonies of gelatinous capsules of great size. Within the gelatinous substance is a chain of small round cells or coccus-like bodies. At intervals along the chain individual members enlarge from time to time and become more prominent than those adjacent. These are the arthrospores. By deliquescence of the gelatinous envelope they are set free, and, soon after, a gelatinous covering again begins to develop around them. This goes on increasing in dimensions. At the same time, the spore in the interior divides, while the new cells arrange themselves linearly as before and repeat the arthrospore method of enlargement.

The occurrence of endogenous formation of ordinary spores within the cholera bacillus has been denied. The bodies which were taken for spores seem to have been merely vacuoles. The formation of arthrospores in chains has been described, however, by Hueppe, and his observations have in a manner been confirmed by Babes and Neisser.

When an organism propagates by sporing it is always more resistant to time and extraneous influences than when it increases merely by fission. The spores can generally be dried and yet retain their virulence. Hence the danger of the disease engendered by the organism being transmitted is enhanced.

Influence of Temperature.

1109. As a rule the growth of the cleft-fungi is facilitated by a temperature higher than that necessary for the moulds and yeasts. Many of them grow at an ordinary summer temperature (anthrax, cholera spirillum); others make satisfactory progress only when it comes up to the range of that of the animal body. The temperature of boiling water is usually rapidly fatal to most of the pathogenic schizomycetes, and probably to all if continued sufficiently long. Some of them, however, *e.g.* bacillus subtilis, withstand it for long. It is in the spore stage that they present this resistance. The bacilli are more readily destroyed.

Influence of the Reaction of the Culture Medium.

1110. Excess of acidity or of alkalinity is injurious. Most of them thrive best on a medium which is carefully neutralised or inclines to the alkaline side. *Bacillus butyricus*, however, can grow in an acid medium, and *micrococcus ureæ* in one which is very alkaline. Some growing in an acid medium to begin with, change it to alkaline and subsequently flourish; others commencing in an alkaline medium, change it to acid and proceed to develop still further. Or, beginning with one which is neutral or faintly alkaline, the organism may flourish until it becomes acid; as this takes place growth ceases.

Powers of Movement.

1111. A large number of the pathogenic schizomycetes are motile. The motility is quite different from the Brownian movement seen in any finely-divided particles suspended in a liquid; it is usually progressive, and would almost seem to be purposive in character. In certain cases it is of a dancing character, in others it is wriggling or screw-like.

When any true vital movement is perceived it may be concluded pretty generally that the organism is provided with motile organs in the shape of cilia or flagella. It is by the lashing of these that locomotion is effected. In some, however, they are apparently absent (de Bary). The cilia not only set up movements which subserve purposes of locomotion, they also excite currents which attract food particles, etc. It is only those individuals having an affinity for oxygen which are endowed with such powers of movement. When they come to the surface, and their hunger for oxygen is satiated, they cease to be motile apparently by losing their cilia.

Staining of Cilia.—This is a matter of great difficulty and of considerable importance; the cilia cannot well be seen in the unstained condition.

Loeffler's method is as follows: Sow the organism to be stained on gélose[1] and place in the culture chamber. Mix a small particle of the culture with a drop of water on a cover-slip. A series of further dilutions is made upon other cover-slips. These are dried in air free from dust. Fix by passing over a naked flame and proceed to colour.

This implies two processes: (1) the application of a mordant, and (2) the staining. The mordant consists of

Aqueous solution of tannin (20 grms. tannin to 80 c.c. water) .	10 c.c.
,, ,, ferric sulphate saturated in the cold . .	5 c.c.
Saturated solution of fuchsin in absolute alcohol	1 c.c.

The colouring solution is composed of saturated solution of fuchsin in aniline water, to which are added a few drops of soda (1-1000), just till opalescence commences.

The mordant is applied by pouring a drop of the solution on a cover-slip held in the forceps, and heating slowly over a small flame for half to one minute. It is not necessary to wait for the drop of liquid boiling; the heating is sufficient when it begins to emit vapour. Wash in distilled water and in absolute alcohol.

Stain by placing a drop of alkalised staining solution upon it and heating carefully for a minute. Wash in distilled water. Leave to dry and mount in balsam.

This, however, is not everything. According to the species of bacterium, it is necessary to modify the reaction of the mordant by adding an alkali (soda to 1 per cent) or an acid (sulphuric acid 1·225 per cent). The number of drops of either solution requires to be apportioned for each microbe. The diverse vibrios, the bac. pyocyaneus, and many varieties of spirillum require the addition of acid; and typhoid,

---

[1] The term gélose is often applied to the agar medium.

b. subtilis, and the b. of malignant œdema and symptomatic charbon, micrococcus agilis, etc., require the medium to be alkalised.

Nicolle and Morax (No. 423, vii. 1893, p. 554) have modified this process as follows. They claim that thereby the staining of the cilia is rendered surer and that the application of the method is simplified: Mix a small particle of the microbe from a gélose culture with a watch-glassful of distilled water. Transfer this to cover-slips. The cover-slips should have been passed several times previously through the Bunsen flame and allowed to cool. If this is not done the liquid gathers in isolated drops. Allow the excess of liquid to run off and dry under cover. Place a large drop of the mordant solution on the cover-slip, heat for twelve seconds or so over a small flame. When vapour appears, discharge the extra solution and wash gently in a stream from a wash-bottle. Repeat this process several times. Colour by placing a drop of Ziehl's solution of fuchsin (vol. i. p. 136) on the cover-slip and heating once or twice for a quarter of a minute. Wash in water and examine in it. If the staining has succeeded, dry the cover-slip and mount in xylol balsam.

One cause of failure in staining cilia is the presence of glutinous substances in the culture. These can be removed in great part by copious dilution with water.

Van Ermengem's process, which is highly to be commended, is as follows:—

(1) There must be absolute *cleanliness of the cover-glasses.* To obtain this, boil in the following solution:—

Potassii bichrom.	60 grammes
Acid. sulphuric. concentrated . .	60 ,,
Water	1000 ,,

Wash several times in water, then in absolute alcohol, and allow to dry in the vertical position under a bell jar *without wiping.*

(2) To obtain good preparations the culture must be fresh. An agar culture of 10-18 hours is best. In making the cover-glass preparation dilute well, so that little organic matter is present.

(3) The fixing bath which gives the best results consists of

Osmic acid (2 per cent solution) . . .	1 pt.
Tannin (solution of 10 to 25 per cent) . .	2 pts.

To every 100 c.c. of tannin solution add 4 to 5 drops of glacial acetic acid. This forms a sort of ink. Put a drop on the cover-glass and leave half an hour in the cold. If heated to 50°-60° C., five minutes is enough.

(4) The preparations, after having been washed very carefully in water and in alcohol, are plunged for a *few seconds* in a bath of nitrate of silver of from 0·5 per cent to 0·25 per cent.

(5) Next, *without washing*, they are passed into a reducing bath, viz.—

Pyrogallic acid	5 grammes
Tannin	3 ,,
Acetate of soda (melted) . . .	10 ,,
Distilled water	350 ,,

After a few seconds' constant shaking of the bath, replace in the silver bath.

It is necessary to stop the operation when the silver bath commences to become black.

Then wash in abundance of water, dry gently between blotting paper, and mount in balsam.

Modification of Van Ermengem's Method by Wilgerodt.

A fresh culture of the organism to be stained is diluted to a weak turbid fluid with water, in doing which, introduction of any of the medium must be carefully avoided. The cover-glasses to be used are cleaned with ammonia, then with pure alcohol, and wiped with a linen cloth, and the surface to be used is heated over a Bunsen burner after removal of any linen fibres with a camel's hair pencil. The fluid is spread with a short platinum Öse of about ½ mm. diameter, so that it becomes well distributed. Then follow drying of the fluid, and placing of the cover-glass for one to twenty-four hours in the following mordant:—

I.

1 part 2 per cent osmic acid solution,
2 parts 20 per cent tannin solution.

After *careful* washing in distilled water and absolute alcohol the preparations are placed for ten to twenty minutes in 10 per cent nitrate of silver solution, are removed singly and washed for about five seconds with distilled water, and are then laid for ten to twenty minutes in the following solution:—

II.

Pyrogallic acid	5 grammes
Tannin	3 ,,
Acetate of soda (water free) . . .	10 ,,
Aq. destill.	350 ,,

After again washing with distilled water, the preparations are introduced *singly* into a watch-glass containing 0·3-0·4 per cent nitrate of silver solution. They are left in this two to three minutes, and during active movement of the fluid in the watch-glass, a solution made by diluting Solution II. with 10 parts of water is allowed to run from a pipette into the watch-glass. After the fluid has become much darkened, the preparation is taken out and washed quickly and carefully with distilled water. The quickness with which the fluid is allowed to run out from the pipette and the moment of removal are important for success.

Sclavo (No. 423, vii. 1893, p. 220) adopts the following:—

He mordants the preparation for a minute at first with a bath containing 1 grm. tannin in 100 c.c. alcohol at 50° C., and conveys it next into an aqueous solution of phospho-tungstic acid for something like a minute. It is then washed rapidly in distilled water, and placed for three to five minutes in the Ehrlich colouring bath, slightly warmed. The proceeding is completed by washing, drying, and mounting in balsam dissolved in xylol.

Cilia and Diagnosis.—Of late a good deal has been made of the presence, character, and number of the cilia as a means of diagnosis of the particular microbe, or, it may be, as in the case of the cholera spirillum, of the particular variety. Nicolle and Morax (No. 423, vii. 1893, p. 554) show, for instance (Fig. 573), that the cilia attached to cholera spirilla taken from different localities differ in number and disposition. In one variety from India they are absent, and this also is the only one which is non-motile. Of the others there are two types, which are indicated as follows:—

(1) A single cilium is situated at one of the extremities of the organism. Samples from Shanghai and Hamburg, from Courbevoie and Angers, follow this type. The vibrio of Finkler-Prior and of Deneke (p. 550), and that of Sanarelli and Blachstein, also present this peculiarity. Loeffler also describes a single cilium in the case of the spirillum of Metchnikoff.

(2) Multiple cilia come off at different parts. Thus the cholera parasite of Massowah, Calcutta, and Paris is characterised by the presence of four cilia coming off two by two at each end. There are sometimes three at one end and one at the opposite. They have never seen a greater number of cilia than this in any example of the cholera spirillum. Cilia, however, are very fragile, and are easily detached by the necessary manipulations.

These two types are not modified by passage through the system of Man or animals. They preserve their distinctive characters under all circumstances. The uniciliated vibrios are ordinarily shorter and more comma-shaped than the pluriciliated.

It has been alleged that the **bacillus coli** can be distinguished from that of typhoid fever by the fact that the former always possesses fewer flagella than the latter. Bacillus coli possesses ordinarily six, and exceptionally eight to ten, while that of typhoid is provided with from ten to twelve. It should be noted, however, that those of bacillus coli are more brittle than those of typhoid.

The cilia are sometimes peculiarly tortuous. Sakharoff (No. 423, vii. 1893, p. 550) describes the cilia of an organism found by him in cholera stools as being remarkable in this respect. He believes, however, that such bacteria represent simply evolutional forms of the organism of cholera asiatica. Their cilia resemble in tortuosity the coils of a spirillum.

Caustic Action upon the Tissues.

1112. Several of the pathogenic cleft-fungi have a cauterising or caustic action on the part in which they live. One of the best examples of an organism of this kind is the tubercle bacillus. In whatever tissues it grows its presence is accompanied by caseation of the part in which it is enclosed. This, although predisposed to by the want of vascularity of tubercle as a tumour, seems nevertheless to be greatly effected through something secreted by the bacillus, and which presumably soaks into the surroundings. It cannot be that the bacillus abstracts the nourishment from the part and causes it to necrose, for in quite young tubercles, in which only individual bacilli can be detected, and these at wide intervals, caseation may have far advanced.

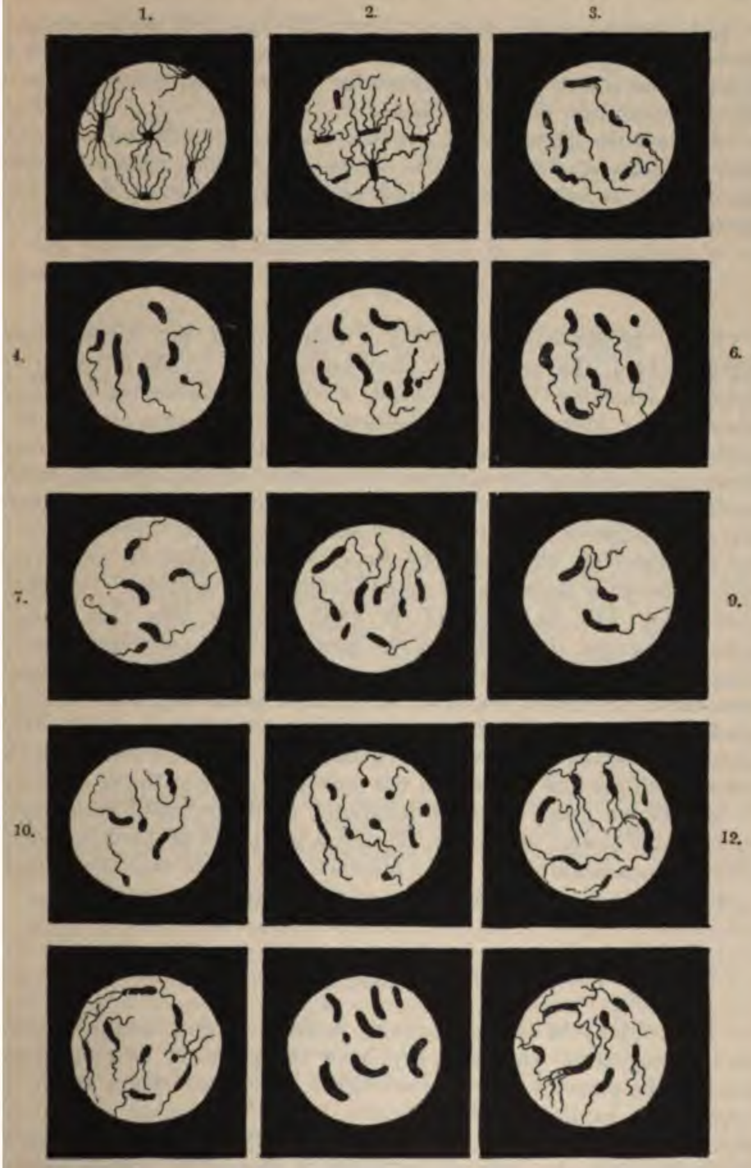


FIG. 573.—CILIATED PATHOGENIC ORGANISMS.

(1) Typhoid fever; (2) bac. coli; (3) b. of Finkler and Prior; (4) b. of Deneke; (5) "vibrio
icide"; (6) v. of Sanarelli (Suresnes); (7) v. of cholera (Angers); (8) v. of cholera (Courbevoie);
v. of cholera (Hamburg); (10) v. of cholera (Shanghai); (11) v. of cholera (Massowah, round
rm); (12) Id. (elongated form); (13) v. of 1884 cholera; (14) v. of Indian cholera (devoid of cilia);
) v. of cholera (Calcutta).

In bacterial necrosis of the liver (p. 235) death of the tissue takes place for a long distance around the deposits of the organisms, and in all likelihood is also to be accounted for by the destructive influence of the secretions from these organisms.

Whether the gummata of syphilis are to be explained upon the same grounds may be a matter of question. The masses of dead tissue found in pseudo-acute yellow atrophy (p. 233) may possibly be due to a like cause.

Influence of Sunlight.

1113. Bright sunlight exerts a retarding if not a destructive influence upon the growth of most microphytes. The following experiment (Buchner, Marshall-Ward, etc.) has a direct bearing upon this subject. Mix a culture of anthrax spores with agar medium, and pour the mixture into a Petri's capsule. Cover the capsule with black paper, and cut out a figure, say a letter of the alphabet, in the paper on the floor. Pass a stream of sunlight reflected from a plane mirror through the aperture for twenty-four hours. Then place in the incubator for three to four days. Colonies grow on every part, unless where the light has streamed through the medium. Marshall-Ward (No. 149, lii. 1892-93, p. 396) believes that the sunlight actually destroys the organism, for portions of the medium removed from the clear area remain sterile even when tube cultures are made from them. So far as his experiments have gone, they show that the effects of the electric light are feebler than that of the sun. This bactericidal action of the sun's rays, moreover, he finds (No. 149, liii. 1893, p. 28), is due to those in the blue-violet half of the spectrum.

Spores are pretty generally admitted to be provided with a protective fatty sheath or investment, and a good part of their resistance seems to be accounted for by its presence. It is said that the sunlight oxidises this and exposes the germ of the spore in the interior.

Pigment-forming Properties.

1114. Many of the cleft-fungi, pathogenic and non-pathogenic, are chromogenous—that is to say, have the power of developing pigment. The pigment is contained either in their substance or in the surrounding medium. Thus Sarcina lutea, Micrococcus luteus, and Micrococcus cereus flavus throw out a golden yellow; Bacillus luteus, Staphylococcus pyogenes aureus, more or less of an orange yellow; Bacillus ruber, bright red; Micrococcus prodigiosus, a rose red; and Beggiatoa roseo-persicina, more of a violet red; Micrococcus cinnabareus, a cinnabar red; Micrococcus roseus, Streptothrix of Eppinger, and Rose-yeast, more of a flesh colour; Bacillus violaceus, a violet black; and Bacillus janthinus, a delicate violet. Many of them afford a green colour, such as Bacillus pyocyaneus, B. fluorescens liquefaciens and non-liquefaciens, and the organism of green diarrhœa of infants. Bacillus fuscus, Cladothrix dichotoma, Spirillum choleræ Asiaticæ, and B. mallei afford a brown. Representations of some of these organisms growing on different media are given in the accompanying coloured plates. Certain of them, as, for instance, that of glanders (Figs. 506 and 507) and cholera (Fig. 492), are uncoloured on one medium, coloured on another. In certain cases the pigment is deposited in the capsule of the organism, in others in the protoplasm in the interior.

Some of these pigments have been isolated, and have received distinctive names, such as *bacterio-purpurin*, *pyocyanin*, etc. Optically, they resemble in some respects aniline dyes; it must not be concluded, however, that they are alike in composition.

Pyocyanin was isolated by Fordos (No. 40, li. 1869, p. 215), has basic characters, and is probably closely allied to the ptomaïnes. The sulphate and chloride crystallise in red needles, and solutions of the same are precipitated by gold chloride, platinum chloride, potassic iodide, mercury chloride, tannin, etc. With ferridcyanide of potassium and chloride of iron, pyocyanin gradually throws down Berlin blue more slowly than morphia. It is soluble in water, particularly so in hot water, in alcohol, and in chloroform, less so in ether. Its solutions have a bitter taste. Exposure to air and all other methods of oxidation cause it to pass into a yellowish-green substance, pyoxanthose, crystallising in small yellow needles. The nature and properties of this yellow colouring matter are not so well known as those of pyocyanin itself. The Bacillus fluorescens liquefaciens and B. fl. putridus also secrete it. Pyocyanin does not seem to be toxic; the organism which secretes it, the Bacillus pyocyaneus, does not appear to take any part in the causation of suppuration, even although it is found growing upon pus. The greenish colour of cultures of the organism in bouillon is due to the development of pyoxanthose. When the organism is cultivated free from oxygen it grows well enough, but the culture liquid is uncoloured by it. The organism, it should be mentioned, is not peculiar to pus, although found oftenest within it. It is also the cause of coloration of blue sweat.

Extraction of Pyocyanin.—Gessard's process is as follows:—Treat the liquid containing it with a little ammonia and with chloroform. To get rid of impurities such as fats, filter and shake with water acidulated with sulphuric or hydrochloric acid. The pyocyanin passes into the water as a red combination, while the chloroform retains the fat and the yellow-green pigment pyoxanthose. The acid aqueous solution is saturated with ammonia or potash; it becomes blue. Filter and treat with chloroform. The chloroform abstracts the pyocyanin; evaporate, and it is left in the form of deep blue crystals like indigo.

Conditions of Secretion.—Organisms develop pigment only when they have free access to oxygen (Liborius). If they are grown in an atmosphere devoid of oxygen, or if the culture liquid is covered with oil, they fail to develop colour. A great deal depends also upon the basis. Thus potato is favourable in most cases, and particularly if it is slightly acid. In some instances, however, an alkaline reaction is preferable. Sunlight is unnecessary.

Photogenous Organisms. — Phosphorescence is a property common to many organisms. The phosphorescent light of *Pelagia noctiluca* is due to the *Bacillus pelagia* which lives in the mucus of its ectoderm. The phosphorescence of decaying fish and other animal matter is caused by the growth of a photogenous organism upon them. It is a property which is common to many varieties, such, for instance, as the Bacillus phosphorescens from sea water in the vicinity of the West Indies and the Bacterium phosphorescens of Fischer. The light is so brilliant when the culture is successful as to enable a person to read by it. It has even been found possible to photograph by means of it.

The best culture fluid is a broth made from fish with sea water. Beyrinck recommends the following, which will be found excellent for the purpose :—Fish broth made with sea water + 1 per cent glycerine, ¼ per cent asparagin, and 8 per cent gelatine.

Fluorescence. — Several of the pigments in question confer another property upon the medium, namely, that of fluorescence. Such is the case with the greenish pigment secreted by the Bacillus pyocyaneus, the pigment of B. fluorescens non-liquefaciens, etc.

Literature on Chromogenous Microphytes.—**Charrin:** La maladie pyocyanique, 1889. **Engelmann:** Arch. f. d. ges. Physiol., xxx. 1883, p. 95; *Ibid.*, xlii. 1888, p. 183. **Fordos** (Pyocyanine): Comptes rend. de l'Acad. des Sciences, li. 1869, p. 215. **Gessard** (Bac. Pyocyaneus): Ann. de l'Inst. Pasteur, iv. 1890, p. 88; *also* (Microbe of Blue Milk), Ann. de l'Inst. Pasteur, v. 1891, p. 737. **Lankaster:** Quart. Journ. Mic. Sc., xiii. 1873, p. 408. **Legrain** (Cultures on Coloured Bases): Ann. de l'Inst. Pasteur, v. 1891, p. 707. **Morat** (Soluble Product of Bac. Pyocyaneus): Arch. de physiol. norm. et path., iv. 1892, p. 386. **Rohrer** (Pigment formed by Bac. Pyocyaneus): Centralbl. f. Bakteriol. u. Parasitenkrank., xi. 1892, p. 327. **Schaefer:** Beitrag z. Lehre v. d. path. Eigenschaften d. Bac. Pyocyaneus, 1891. **Schimmelbusch** (Green Pus and Bac. Pyocyaneus): Samml. klin. Vorträge, 1893, No. 62 (Chir. No. 15, p. 303). **Wasserzug** (Bac. Pyocyaneus): Ann. de l'Inst. Pasteur, i. 1887.

Gas-forming Properties.

1115. When growing in the tissues or upon the contents of the stomach and intestine, certain of the organisms at present being considered have the property of evolving gas. Such, for instance, are those of symptomatic anthrax and of the so-called "Scum-liver" (Schaumleber). In the former case the gas gets into the subcutaneous areolar tissues and gives rise to a crackling swelling; in the latter, according to Ernst (No. 13, cxxxiii. 1893, p. 308), a small bacillus fructifies in the liver, causing it to be filled after death to such an extent with gas-bells that a foamy deposit can be scraped from the cut surface. Those which flourish within the alimentary canal have already been referred to (p. 497).

The gases evolved consist of carbonic acid, light carburetted hydrogen, and hydrogen.

THE SOIL AS A HARBOURER OF PATHOGENIC ORGANISMS.

1116. Many pathogenic organisms can live in the soil, and apparently multiply within it. Thus the organisms of malignant œdema, of tetanus, and of anthrax may all be obtained from soil. The spores of anthrax may live for years within it apparently unharmed. The organisms of suppuration are also sometimes derived from it.

The surface microbes appear to be mostly aerobic, those which are deeper down anaerobic. The latter extract their oxygen from oxygen containing compounds, a property which, like that possessed by others of extracting free nitrogen from the atmosphere, they have probably acquired as a matter of necessity. Very deep levels of the soil (12 feet) seem to be incapable of supporting bacterial life, and are generally sterile as a consequence.

MUTUAL ANTAGONISM OF MICROPHYTES.

1117. A most interesting and practical question comes to be whether the growth of one organism in the blood can be prevented by that of another. Reference has been made already (p. 156) to the work of Cantani in this direction. He employed the organisms of putrefaction against the bacillus of tuberculosis. The results were not very encouraging. Possibly it may be that the bacillus of tubercle is too strong for those of putrefaction, for, as before alluded to (p. 145), tubercular tissues do not exhibit evidence of putrefaction, even although they may be falling to pieces and in process of being converted into phthisical cavities. Growing side by side with the tubercle bacillus, in the discharge from these cavities, numerous other organisms may be found. But they do not appear to exert any inhibitive action upon its vitality. In the discharge from the vulva or urethra infected with gonorrhœa many cocci besides those of Neisser are found. Some of them are present in the urethra naturally. Such, for instance, are Micrococcus lacteus faviformis (normal vagina), M. subflavus (lochia), M. albicans amplus (rarely in vaginal mucus and in simple urethritis), M. albicans tardissimus (urethral discharges), M. citreus conglomeratus (blenorrhagia). These all grow side by side with the gonococcus, and do not interfere with it.

Indeed we know that the virulence of the diphtheria bacillus gradually dies out unless it is grown along with other organisms.

Notwithstanding this, however, there is always the question as to whether *particular* organisms may not be found which are inimical to the growth of others. To the solution of this question Pawlowsky (No. 13, cviii. 1887, p. 494) and Emmerich and Di Mattei (No. 11, v. 1887, p. 653) have addressed themselves. Anthrax was the organism selected in both cases for experiment. Pawlowsky found that anthrax bacillus, mixed with various other organisms and injected subcutaneously, failed to set up the disease. Of all the organisms he employed, Friedländer's Diplococcus pneumoniæ fibrinosæ was most effectual; Staphylococcus pyogenes aureus came next. Thirdly, even a non-pathogenic organism, such as Bacillus prodigiosus, in some cases prevented the occurrence of the disease. Fourth in order came Streptococcus erysipelatosus. When the counteracting organism was injected into the circulation, he found that most success attended the employment of pneumonia diplococci.

A great deal depends upon the strength of the organism employed as the curative agent and also the quantity injected. Emmerich and Mattei found that the coccus of erysipelas was particularly inimical to anthrax, and that its effect was far more remarkable when it was taken directly from a person dead of erysipelas. Injections of this organism have been said to have a retrogressive effect upon the growth of malignant tumours. An animal prepared by the injection of erysipelas coccus into its subcutaneous areolar tissue is proof against anthrax injected in a like fashion, even in large doses. The anthrax bacilli disappear, and they suppose they are destroyed at the point of injection before they have had a chance of entering the blood- or lymph-channels.

FERMENTATION.

1118. **Definition.**—By it is meant *a process whereby complex chemical compounds are split up into those which are simpler.* It is accompanied by the liberation of heat. During the process the atoms pass from an unstable to a stable condition. It is caused by the action of a ferment.

Ferments.—These are of two kinds: (1) living and organised, as in the case of the yeast plant; and (2) enzymes (ἐνζύμη, leaven) or substances secreted by living cells.

In the case of the first or organised ferments the substance to be fermented probably passes into the cell, and is transformed into less complex molecules in its protoplasm. These are rejected or accumulate as a residue, and it usually happens that when they have accumulated up to a given point, they exert a deterring influence upon the further action of the organism producing them and fermentation ceases.

Thus when the alcohol in alcoholic fermentation amounts to something like 14 per cent its formation ceases; when carbonate of ammonia accumulates to about 13 per cent in ammoniacal fermentation, the further progress of the fermentation is frustrated. In the lactic acid and butyric acid fermentations the same thing happens.

It must not be supposed, however, that a living ferment like the yeast plant is capable of existing entirely upon the substance it ferments. Yeast sown upon pure sugar fails to bring about fermentation and soon dies. Like other living and growing organisms, the yeast plant requires a free supply of proteid to maintain itself upon. This is always contained in solutions capable of being fermented by it.

The members of *the second group or that of the enzymes* act differently. When, for instance, the liquid in which the spirillum of Asiatic cholera has been grown is separated from the organism and added to gelatine medium it liquefies the gelatine, owing to its containing a soluble enzyme secreted by the spirillum.

It is sometimes said, however, that the difference in the action of the two kinds of ferment is only superficial. It has been asserted that yeast yields a ferment, invertin, which, quite apart from the living principle of the yeast, is capable of converting cane sugar into invert sugar (a mixture of left rotating sugar and of dextrose). Further corroboration of the assertion, however, would be required.

These enzymes are formed largely in the animal body as a result of the action of living cells, and are utilised in the preparation of the various food stuffs for assimilation and for other purposes. It should be remembered that all enzymes are readily destroyed by heat.

The chief varieties are: (1) *the diastatic*, converting starch into sugar; (2) *the proteolytic*, rendering insoluble proteids soluble; (3) *the glucosic*, transforming glucosides (compounds of sugar and an aromatic principle) into sugar and simple benzole derivatives; and (4) *the inverting*, changing cane sugar into grape sugar.

Continuous Fermentations.

It sometimes happens that the products of one kind of fermentation act as the pabulum for a second, and it may be a third. Thus starting with sugar, the yeast plant may convert it into alcohol, the bacillus aceti splits up the alcohol and transforms it into acetic acid. After all the alcohol has been consumed, the bacillus aceti can attack the acetic acid and burn it completely into carbonic acid and water. Or it may happen that the acetic acid stage is carried a step further by the access of putrefactive organisms.

Nature of the Chemical Interchanges.

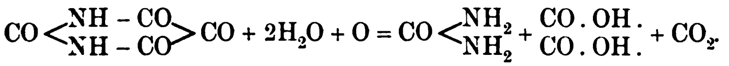
In the various fermentative processes the chemical action apparently is not always alike.

Thus in the ordinary fermentation of grape sugar the essential nature of the process may be described as that of *transference of the oxygen atom from the hydrogen to the carbon atom.* Thus:—

$$C_6H_{12}O_6 + 2(H_2O) = 2(C_2H_6O) + 2(CO_3H_2) = \\ 2(C_2H_6O) + 2CO_2 + 2H_2O.$$

Grape Sugar. Alcohol.

In that just mentioned, the fermentation of alcohol into acetic acid by the bacillus aceti, the essential part of the interchange is one of oxidation. The decomposition of alloxan into urea, oxalic acid, and carbonic acid, and the further splitting up of the oxalic acid under the influence of oxygen into carbonic acid and water, is another example of the same:—



$$CO<\begin{matrix}NH-CO\\NH-CO\end{matrix}>CO + 2H_2O + O = CO<\begin{matrix}NH_2\\NH_2\end{matrix} + \begin{matrix}CO.OH.\\CO.OH.\end{matrix} + CO_2.$$

Alloxan.

This variety may be named, therefore, *fermentation by oxidation.*

In other cases, however, the access of oxygen is unnecessary ; it is absolutely hurtful. The essential chemical interchange in these cases is one of reduction. As an example, butyric acid fermentation by the bacillus butyricus (vibrion butyric of Pasteur) may be mentioned. This organism has been shown to have the power of transforming lactic acid, sugar, and amylaceous substances such as cellulose into butyric acid. The fermentation is fulfilled only in the absence of oxygen, although other organisms may attain the same end in its presence (*e.g.* Bacillus violaceus of Macé). The interchange in this case must be different from that in the example of fermentation by oxidation just given, and may be called *fermentation by reduction.*

In yet other forms of fermentation the molecule splits into two equal parts. The urea molecule, for instance, splits into two molecules of carbonate of ammonia under the influence of the micrococcus ureæ or some other living ferment. This is known as *fermentation by cleavage* (Macé).

The action of the various enzymes, on the other hand, is in most cases really one of hydration, or rather of hydrolysis, as shown by the following examples :—

Diastatic fermentation :—

$$\underset{\text{Starch.}}{C_{24}H_{40}O_{20}} + 3H_2O = \underset{\text{Dextrine.}}{C_6H_{10}O_5} + \underset{\text{Dextrose.}}{3C_6H_{12}O_6}.$$

Emulsin fermentation :—

$$\underset{\text{Salicin.}}{C_{13}H_{18}O_7} + H_2O = \underset{\text{Dextrose.}}{C_6H_{12}O_6} + \underset{\text{Saligenin.}}{C_6H_4 . OH . CH_2OH}.$$

Invert fermentation :—

$$\underset{\text{Cane sugar.}}{C_{12}H_{22}O_{11}} + H_2O = \underbrace{C_6H_{12}O_6 + C_6H_{12}O_6}_{\text{Grape sugar.}}.$$

The following half-tabular statement of the various fermentations which concern us is given by M'Fadyean (No. 161, 1889, p. 494).

(A) **Fermentations produced by microbes** and analogous to the action of enzymes :

(1) Diastatic fermentation, *e.g.* bacillus acidi lactici.

(2) Invert fermentation, *e.g.* penicillium and aspergillus ; yeast fungi.

(3) Cellulose fermentation, *e.g.* vibrio rugula. It is probable that cellulose is dissolved in the digestive tract by ferment bacteria.

(4) "Peptonising" fermentation, *e.g.* the bacteria which liquefy gelatine.

(5) Milk fermentation (curdling of milk), *e.g.* bacillus acidi lactici. It splits the milk sugar into lactic and carbonic acids, and the acid produces a precipitation of the casein.

(6) Urea fermentation, *e.g.* micrococcus ureæ. The urea is converted into carbonate of ammonia.

(B) **Strictly organic fermentations.**

1. *Alcoholic fermentation of sugar by the yeast fungi.* It takes place in-

glucoses having the general formula $C_6H_{12}O_6$; and after hydration in maltose $C_{12}H_{22}O_{11} + H_2O$.

To understand the process one must know the chemical structure of the carbohydrates. The carbohydrates contain six or a multiple of six atoms of carbon, and in them the relationship of the hydrogen and oxygen is the same as in water. There are three groups:—

1. Glucose group, *e.g.* dextrose $C_6H_{12}O_6$
2. Cane sugar group, *e.g.* maltose $C_{12}H_{22}O_{11}$
3. Cellulose group, *e.g.* starch $(C_6H_{10}O_5)_n$.

All these are fermentable, but only the first group can be converted by the yeast fungi into alcohol. The last two groups can be converted by *other* ferments into bodies capable of undergoing alcoholic fermentation. Thus:—

(1) *Starch* by the action of an enzyme can be converted into *maltose*—

$$\underset{\text{Starch.}}{3C_6H_{10}O_5} + H_2O = \underset{\text{Maltose.}}{C_{12}H_{22}O_{11}} + C_6H_{10}O_5.$$

(2) *Maltose* by the action of an enzyme formed by the torula is changed into a *glucose*—

$$\underset{\text{Maltose.}}{C_{12}H_{22}O_{11}} + H_2O = C_6H_{12}O_6 + \underset{\text{Dextrose.}}{C_6H_{12}O_6}.$$

(3) The *torula* acting on the *dextrose* converts it into *alcohol* and carbonic acid—

$$C_6H_{12}O_6 = 2C_2H_6O + 2CO_2.$$

By-products are formed as well in this last change, namely, glycerine, succinic acid, fusel oil, acetic acid, etc., so that this last change is not so simple as represented by the formula. When the alcohol reaches 12 per cent, the torula is hindered in its development, when it reaches 14 per cent further fermentation ceases. The by-products may possibly be metabolic products of other microbes.

II. *Fermentation by Schizomycetes:*—

(*a*) Lactic acid fermentation by, *e.g.*, Bac. acid. lactici. Glucoses are converted into lactic acid, and carbonic acid is given off. When the lactic acid reaches 0·8 per cent and is not neutralised fermentation stops. It is probable that the bacillus hydrates the *sugar* in the milk, *i.e.* converts it into a glucose, before the special fermentation takes place. The formula usually given is—

$$C_6H_{12}O_6 = \underset{\text{Lactic acid.}}{2(C_2H_4 . OH . COOH)}.$$

But this does not explain the formation of *carbonic* acid. Perhaps it is due to the action of a second bacterium.

It should be mentioned that milk which has been boiled turns bitter, that which has not turns sour. Of the various forms of organism which vegetate in milk the most active at a low temperature is the bacillus acidi lactici. It imparts sourness to the milk by forming lactic acid. It is killed, however, by boiling, according to de Bary (No. 589, p. 33), while the spores of the bacillus of butyric acid fermentation are able to withstand a boiling temperature. They retain their vitality in the boiled milk, and occasion the bitter taste by the fermentation they excite.

(*β*) Butyric acid fermentation by, *e.g.*, Bacillus butyricus, B. amylobacter, or Clostridium butyricum, by which starch, cane sugar, and dextrose are fermented. The one important product is butyric acid—$C_4H_8O_2$; but along with it we find acetic acid, alcohol, carbonic acid, and hydrogen. The bacillus butyricus produces the change anaerobically.

(γ) Mannite fermentation by, *e.g.*, micrococcus viscosus. This produces viscosity in wine by acting on the sugar, and forming a peculiar gummy body, viscose.

Amongst other fermentations may be mentioned the conversion of glycerine into alcohol, and of fatty acids into propionic and acetic acids.

Finally, the conversion of the *alcohol* in fermented liquors into acetic acid by the bacillus aceticus—

$$CH_3 . CH_2OH . + O_2 = \underset{\text{Acetic acid.}}{CH_3 . COOH} + H_2O.$$

Literature on Fermentation.—**Arthus** (Vital and Chemical Fermentations): Compt. rend. Acad. d. sc., cxv. 1892, p. 839; *also*, Arch. de physiol. norm. et path., iv. 1892, p. 651. **Bourquelot**: Les Fermentations, 1889. **Calmette** (Ferments of Starch): Ann. de l'Inst. Pasteur, vi. 1892, p. 604. **Chauveau** (Ferments and Virus): Rev. scient., iii. 1881, p. 234. **Duclaux**: Ferments et maladies, 1882; *also*, Fermentation (Health Exhibition Handbook, London, 1884). **Falk** (Ferments in Animal Organism): Arch. f. path. Anat., lxxxiv. 1881, p. 119. **Flügge**: Fermente und Mikroparasiten (Eng. Transl. by Cheyne), 1890; *also*, Fermente u. Mikroparasiten, 1883; *also*, Handbuch d. Hygiene, Pt. I., Fermente u. Mikroparasiten, 1882. **Frankland** (Some Fermentations excited by Specific Micro-organisms): Tr. VII. Internat. Cong. Hyg. and Demog., 1892, ii. p. 310. **Grützner** (Unformed Ferments in Animal Body): Arch. f. d. ges. Physiol., xii. 1876, p. 285. **Herzen** (the Rôle of Microbes in Fermentation): Compt. rend. Soc. de biol., 1889, i. p. 140. **Hildebrandt** (Action of Hydrolytic Ferments): Arch. f. path. Anat., cxxi. 1890, p. 1; *also* (Hydrolytic Ferments), Arch. f. path. Anat., cxxxi. 1893, p. 5. **Jacobson**: Ueb. ungeformte Fermente, 1891; *also* (Soluble Ferments), Ztschr. f. physiol. Chem., xvi. 1891-92, p. 340. **de Jager** (Action of Unformed Ferments): Arch. f. path. Anat., cxxi. 1890, p. 182. **Kellner** (Invert Ferments): Ztschr. f. physiol. Chem., xiv. 1889-90, p. 297. **Kirchner** (Identity of Streptococcus P. and S. Erysipelatosus): Centralbl. f Bakteriol. u. Parasitenkrank., xi. 1892, p. 749. **Liebig**: Ueb. Gahrung, etc., 1870. **Lister** (Lactic): Trans. Path. Soc., xxix. 1878; Contribution to the Germ Theory of Putrefaction and other Fermentative Changes, 1875; Quart. Journ. Micr. Sc., xiii. 1873, p. 380; *Ibid.*, xviii. 1878, p. 177; *also* (Lactic Acid Fermentation), Trans. Path. Soc. Lond., xxix. 1878, p. 425. **Nägeli**: Theorie der Gahrung, 1879. **Pasteur**: Etude sur le vin, 1866; Etude sur la bière, 1876; *also* (Lactic), Compt. rend. Acad. d. Sc., xlv. 1857, p. 913; Studies on Fermentation, 1879. **Schützenberger**: Die Gahrungserscheinungen, 1876. **Trouessart**: Microbes, Ferments, and Moulds, 1886. **Tyndall** (F. and Disease): Pop. Sc. Month. N. Y., x. 1877, p. 789. **Wassilieff**: Ztschr. f. physiol. Chem., vi. 1882, p. 112. **Wood**: Lab. Rep. R. Coll. Physicians, Edin., 1890, p. 253.

CHAPTER XCIV

SYSTEMATIC BACTERIOLOGY—(*Continued*)

PUTREFACTION.

1119. **Definition.**—By putrefaction is meant *the process of decomposition to which organic matter is subject after death.* It is accompanied by the evolution of foul-smelling gases, and consists in *the sum of the fermentations excited by certain micro-organisms upon tissues of an albuminous or albuminoid type.*

The albumin in the course of putrefaction never seems to be decomposed directly but is transformed primarily into peptone. By the addition of pancreatic ferment putrefaction is hastened. The albumins are most readily attacked, but gelatinous and gelatine-yielding tissues—that is to say, albuminoids—are also disposed to it. Like all fermentations, putrefaction takes place only in presence of water. The reason of this is that it is largely a process of hydration. Hence, if the tissue is dried, it can be kept free from putrefaction for an unlimited time.

It is in many respects a salutary phenomenon, consisting as it does in the reduction of compound products to those which are simpler, so rendering them capable of being assimilated by plants. It is even said that the organisms of putrefaction subserve a useful purpose in the animal economy by hydrating the food elements in the alimentary canal. All the products of digestion can be evolved by them outside the body, and certain physiologists have gone so far as to say that they, and not the natural secretions of the digestive glands, are the essential elements of digestion. Under no circumstances of health, however, do these organisms seem to exist in the blood or internal tissues.

The Organisms.—It used to be said that there was one organism of putrefaction, namely, **bacterium termo.** It is now conceded, practically on all hands, that this is not a pure form, that the small cylindrical body so designated is nothing more than a stage in the life history of several different organisms. The truth seems to be that there are many organisms which have the property of inducing putrefaction.

Rosenbach (No. 648), for instance, isolated three, to which he gave the generic name Bacillus saprogenes, distinguishing them as 1, 2, and 3 respectively. All of them have the property of calling forth putrefaction.

Hauser (No. 649) finds, on sowing some of the liquid derived from putrefying substances on the surface of gelatine plates, that many different colonies develop upon it. Most of these fail to liquefy the gelatine, but there is one met with in great constancy which does so, and which he regards as among the most important causes of putrefaction. He gives it the name **Proteus,** from the many forms it assumes. Thus, beginning as a coccus-like structure, it may pass successively through the stages of a short rod, a long rod, a thread, a vibrio, a spirillum, and a spirochæta. The multiformity of the organism is dependent apparently upon, and is regulated by, the nature of the basis on which it is growing, so that, for instance, when grown on an acid basis, only cocci and short rods are forthcoming. He distinguishes three species, P. vulgaris, P. mirabilis, and P. zenkeri. They belong to the class of facultative anaerobes. Proteus vulgaris and mirabilis are amongst the chief promoters of putrefaction.

They can be subdivided into those which are aerobic and those which are anaerobic. *The aerobes* grow luxuriantly at first all through, let us say, an infusion of muscle, but as the oxygen becomes exhausted they pass to the surface, where they localise themselves often in the form of a film. *The anaerobes* can now flourish in the deep parts of the liquid unopposed and protected by the film of aerobes on the surface.

The elements of the medium can be entirely oxidised by the aerobes, and converted into inodorous substances such as carbonic acid and water.

Those acted on by the anaerobes are naturally less completely oxidised and are much more complex. Briefly summarised they are as follows:—

(1) Hydration products: Leucin, peptone, amido-valerianic acid, tyrosin, glycocol.

(2) Volatile products: Ammonia, volatile fatty acids, and reduction gases such as hydrogen, sulphuretted hydrogen, and marsh gas.

(3) Characteristic putrefactive products: Skatol, indol, and phenol.

(4) Basic compounds or ptomaines.

Hydrogen is liberated and combines with sulphur in its nascent condition, or with phosphorus, to form respectively sulphuretted or phosphuretted hydrogen. These add to and confer a special character upon the odour.

The fact of the presence of phenol, indol, skatol, etc., led to the suggestion (Nencki) that these products put a stop to the further development of the microbes of putrefaction. So comparatively small a percentage as 0·05 of skatol or 0·1 of indol is sufficient to arrest their development, but in putrefactive liquids they are in smaller proportion than this. As demonstrated by Baumann, phenol is a very constant product of putrefaction and its presence in the intestine has been proved by Brieger. The amount increases in septicæmia and in peritonitis.

Literature on Putrefaction and Disease.—**Bordas**: Étude sur la putréfaction, 1892. **Brieger** (Relationship of Putrefaction to Disease): Ztschr. f. klin. Med., iii. 1881, p. 465. **Eber** (Chemical Property of Putrefaction): Arch. f. wissensch. u. prakt. Thierh., xvii. 1891, p. 222. **Hiller**: Die Lehere v. d. Fäulniss, 1879. **Hueppe** (Relation of Putrefaction to Infectious Diseases): Berl. klin. Wochnschr., xxiv. 1887, p. 721. **Lister**: A Contribution to the Germ Theory of Putrefaction, 1875 (Repr. from Tr. Roy. Soc. Edinb., xxvii.). **M. Duncan** (Sapræmia): Lancet, 1880, ii. p. 684. **Sanderson**: Suppl. Loc. Gov. Board Reports, 1883, p. 101. **Tyndall**: Essays on the Floating Matter in the Air in relation to Putrefaction and Infection, 1881. **Winogradsky** (Organisms of Nitrification): Ann. de l'Inst. Pasteur, iv. 1890, p. 213. **Zahn** (Putrefactive Germs in Blood): Arch. f. path. Anat., cxxxv. 1884, p. 401.

THE CHEMICAL PRODUCTS OF BACTERIAL GROWTH.

1120. Among the many products of the metabolism effected by micro-organisms there are certain which act as violent poisons, others which are harmless. An accurate classification, from a chemical point of view, as yet is impossible, but three distinct classes have up till the present time been recognised, namely, (1) the **bacterial alkaloids** or **ptomaïnes,** (2) the **enzymes** or **ferments,** and (3) the **albumoses.** They are sometimes developed singly, at other times in combination. Anthrax elaborates both a ptomaïne and an albumose. The ptomaïne, according to Martin (No. 6, 1892, i. p. 641), induces fever, the alkaloid coma.

The alkaloids are a common source of danger, from their developing in animal articles of diet such as fish, sausages, ham, etc., as a result of putrefaction.. It is probable that the active poisons of typhoid, of Asiatic cholera, and of many other diseases, are of this nature.

The albumoses seem to be alike in composition with those developed in peptic digestion. They are a common cause, apparently, of the phenomena of various diseases such as diphtheria, anthrax, etc. The snake-poison is of this nature.

The enzymes or ferments are secreted by a large number. They are not poisonous in themselves, but by acting upon proteids convert these into albumoses which are highly poisonous.

The history of the subject of bacterial poisons really begins (1856) with the publication of Panum's paper on the poison of putrid flesh (No. 631). He came to the conclusion that the putrid poison from the flesh of the dog is not volatile, that it is not destroyed by boiling, that it is soluble in water but not in alcohol. Further, that the albumin-like substances present in the liquids from such putrid flesh are not in themselves poisonous, but that the poisonous properties depend on a substance mixed with them. He found the intensity of this poison to be very great, comparable in this respect to snake-poison, curare, and certain vegetable alkaloids.

When injected in sufficient quantity into the jugular vein it induced violent cramps and involuntary evacuation of the bowels and bladder. The respirations were laboured and there was pallor, sometimes cyanosis, and depressed pulse. The pupils were dilated and the eyeballs projected. The carcases of animals experimented upon putrefied rapidly.

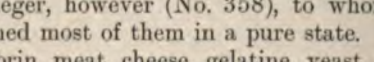
In addition to this putrid poison, Panum was able to separate a substance having a narcotic action. This he was enabled to do on account of its solubility in alcohol. When the dried residue, dissolved in water, was injected into the jugular vein of a dog the animal fell into a deep sleep, from which it awoke in about twenty-four hours apparently uninjured.

Since then our knowledge of this subject has greatly advanced, chiefly through the labours of Bergmann and Schmiedeberg, Gautier, Nencki, Brieger, Selmi, Richardson, Martin, Hunter, and others. But although the information obtained of late years is a great advance upon that of bygone times, yet it must be confessed that we have still much to learn.

I. *The Microbal Alkaloids or Ptomaines.*

1121. The term Ptomaïne (πτῶμα, a cadaver) was applied by Selmi to certain chemical compounds having basic properties, and generated by the action of bacteria on dead proteid matter. Like inorganic and vegetable bases, they combine with acids to form salts. They are sometimes known as *Putrefactive Alkaloids* from the fact that, in their chemical constitution, they resemble ordinary alkaloids derived from the vegetable kingdom. They are built upon the amine type, and are to be regarded as ammonia substitution compounds. They are developed not only during putrefaction, but also during the other decompositions following upon the action of bacteria. In seeking for an explanation of their genesis, the one which seems most feasible is that they are among the transition products which complex organic substances pass through in being broken up into those which are less complex, the final products being carbonic acid, ammonia, and water. The variety of combinations the carbon atom may take part in during its long progress towards this end is truly marvellous. At one time it enters into the constitution of a violent poison, at another the substance of which it forms part is quite inert.

Brieger (No. 632) found that it is only in the early stages of putrefaction that these ptomaïnes prevail. They appear about the seventh day of putrefaction. After eight or ten days the only remaining product which might be called toxic is ammonia.

Nencki (No. 357) appears to have been the first to isolate a member of the group in a pure condition, and to determine the first formula. It was obtained from decomposing gelatine, and had the composition $C_8H_{11}N$ probably built up as  $C_6H_4 < \begin{matrix} CH_3 \\ CH_2 - NH_2 \end{matrix}$.

It is isomeric with collidin, but differs from it in other qualities.

It is Brieger, however (No. 358), to whom the credit is due of having obtained most of them in a pure state. He derived them from putrefying fibrin, meat, cheese, gelatine, yeast, etc.

Classification.—Some of them are violent poisons, others are quite harmless, and a system of classification has been founded in accordance with this. Brieger restricts the term **Ptomaïne** to those which are non-poisonous, and employs that of **Toxine** to those which are poisonous.

The more oxygen supplied, the less poisonous they appear to be. Pasteur asserts that those which are developed with complete exclusion of oxygen are the most toxic of all. Wood made out that the quantity of toxine derived from Asiatic cholera spirillum is much greater when the supply of oxygen to the organism has been meagre than when it has been free.

Another system of classification is founded upon their chemical composition. They all contain C, H, and N, and some of them are composed exclusively of these elements. These have accordingly been included in one group. Another set, however, contains O in addition, and they have been collected in another group.

(A) *Of the non-poisonous*, Brieger (No. 632) distinguished—

1. **Neuridin,** $C_5H_{14}N_2$—very common, obtainable from putrefactive meat, cheese, and gelatine. In specially large quantities from decomposing human organs after three days. It is a diamin which splits into dimethylamin and trimethylamin. Distinguished by forming a double salt with picric acid difficult to dissolve.

2. **Gadinin,** $C_7H_{17}NO_2$—obtained from decomposed fish. Constitution still unknown.

3. **Cadaverin,** $C_5H_{14}N_2$—from decomposed cadaver. Traces found from fourth day onwards, becoming more abundant at tenth to twelfth day. Has a disagreeable odour like coniin.

4. **Putrescin,** $C_4H_{12}N_2$—resembles the foregoing.

5. **Saprin,** with same composition as cadaverin, but distinguished from it by the properties of its HCl compound and those of its gold salt.

6. **Cholin,** $C_5H_{15}NO_2$—found in first days of decomposition of cadavera. Is to be reckoned as Trimethyloxäthylammoniumoxydhydrate $(CH_3)_3 . N . OH . C_2H_4 . OH$. Apparently a product of disintegration of lecithin.

The majority of these cadaveric ptomaïnes are *diamines* and are of simple composition. They differ in these respects from the vegetable alkaloids. Most of them are free from poisonous properties. One, mydalein, however, is toxic.

(B) *Of the poisonous* he distinguished the following:—

1. **Peptotoxin,** the poisonous principle of many peptones. It is a product, for instance, of the artificial digestion of fibrin by gastric juice. Composition unknown. Frogs and rabbits die under its influence with paralysis and insensibility. Can also be produced by the peptonising action of bacteria upon albumin, although this is not definitely proven.

2. **Neurin,** $C_5H_{13}NO$—obtained from putrefying meat after five to six days. Formerly often mistaken for cholin, but is distinguished from it by possessing one molecule less water. Is to be regarded as Trimethylvinylammoniumoxydhydrate $(CH_3)_3 . C_2H_3 . N . OH$ (Vinyl group$= \begin{matrix} CH_2 \\ \| \\ CH- \end{matrix}$). Neurin is poisonous for frogs and mammals in small doses. For 1 kilo cat the fatal dose is 5 milligr. The symptoms are salivation, dyspnœa, acceleration followed by sinking of heart's action, marked intestinal peristalsis with diarrhœa, and lastly, convulsions and collapse. The

features of the poisonous symptoms approach nearest to those of muscarin. Atropin is the best antidote.

It is probably derived from the cholin of lecithin by separation of water, and this separation seems to proceed under the influence of several bacteria of putrefaction.

3. A substance similar and isomeric with **æthylendiamin** with the formula $C_2H_4(NH_2)_2$. Derived from the putrefaction of fish.

4. **Muscarin,** $C_5H_{15}NO_3$—long known as a product of poisonous mushrooms. An oxidation derivative of cholin. Found by Brieger also as a product of fish putrefaction.

5. After a lapse of seven days, better after two to three weeks' continuance of putrefaction, Brieger found toxic bases in cadavera. Two ptomaïnes are recognisable whose analysis has as yet not been completed. The one induces copious diarrhœa in rabbits; the other, named mydalein, induces dilatation of the pupil, injection of vessels of the ear, elevation of temperature, copious salivation and diarrhœa, lastly, panting respiration, lowering of temperature, and death.

After fourteen days' decomposition he found the substance **Mydalein,** a substance which differs from the foregoing in having a specific toxic action. From a cadaver kept at a temperature of - 9° to + 5° for four months, he isolated the substance **Mydine** ($C_8H_{11}NO$), the toxic substance **Mydatoxine** ($C_6H_{13}NO_2$), also the poison **Methyl-guanidin.**

The poisonous principle contained in mussels is **Mytilotoxin** ($C_6H_{15}NO_2$).

Sepsin was separated originally from putrid yeast by Bergmann and Schmiedeberg (No. 50, vi. 1868, p. 497), afterwards from putrefying blood as a sulphate. Dissolved in water and injected into the jugular vein of a dog, it induced vomiting and diarrhœa with evacuation of blood. It is not found in pus. Its composition remains unknown, as it has never been obtained in sufficient quantity. It must not be confounded with Panum's *putrid poison*, which probably was an impure substance.

(C) *From pure cultures of specific bacteria* Brieger was able to isolate the following bases :—

1. **The bacilli of typhoid,** cultivated on beef-tea, do not call forth any indications of putrefaction; there is an absence of development of H_2S, indol, and phenol. A new ptomaine, however, can be obtained from the culture whose gold double salt was easily isolated, but whose further analysis is as yet unknown. It caused salivation in guinea-pigs, rapid breathing, dilatation of the pupil and diarrhœa. The post-mortem examination showed the heart to be in a state of systolic contraction.

2. **Staphylococcus pyogenes aureus,** cultivated on beef-tea retained at a temperature of 30-35 C. for something like four weeks, furnished a base which was harmless, which did not unite with gold chloride, but which formed a crystalline compound with platinum chloride capable of being analysed. Nothing further known.

3. **Tetanus.** By mixing the hashed-up flesh and pus from a tetanic animal he was able to isolate (*a*) a base having the formula $C_{13}H_{30}Az_2O_4$, to which he gave the name **Tetanine.** If a sufficient quantity of this is introduced into the system of animals they die soon. (*b*) Another toxine, which he named **Tetanotoxine,** having the formula $C_5H_{11}Az$. Its physiological effects are the same as the foregoing. Finally, four other substances, namely, **Cadaverine, Putrescine, Spasmotoxine,** and a fourth having the property of determining abundant salivary and lacrymal secretion.

5. **Cholera.**—Brieger found *cadaverin* in cultures of the comma bacillus. In older cultures he also found putrescine. These, however, are not poisonous; they are common products of putrefaction. Besides these he believed that the cultures contained two poisonous substances, one of them being a diamin.

Nicati and Rietsch (No. 40, xcix. 1884, p. 928; also, No. 633) drew attention to the effects produced on animals by the products resulting from the growth of the comma bacillus. They believed that the cultures contained a poisonous substance. This when injected into the circulation of dogs gave rise to effects which chiefly influenced motion. The animal was unable to stand or walk, apparently from motor paralysis. Petri's researches tend to show that among other products of the action of the spirillum of Asiatic cholera there are poisonous bases and a proteid. The latter induces rapidly fatal symptoms in guinea-pigs, chiefly muscular tremors and paralysis. He attributes the symptoms of cholera to this rather than to the bases.

5. **Tubercle.**—The glycerine extract, or **Tuberculin,** of a culture of tubercle bacillus contains substances having a highly important physiological action. The same substance or substances can be extracted from tubercular tissues (Crookshank, No. 192, xlii. 1891, p. 337).

Crookshank and Herroun (No. 6, 1891, i. p. 401) have separated a ptomaïne and an albumose from the crude glycerine extract of cultures. When the ptomaïne is injected hypodermically into tubercular guinea-pigs it induces a rise of temperature; in healthy animals slight indication of depression of temperature. The albumose excites a marked rise of temperature in tuberculous guinea-pigs. In one instance, in a healthy animal, it also brought about a fall in the temperature. The effect on the tuberculous glands in the cases associated with rise in temperature was to render them well defined, indurated, and painful.

6. **Glanders.**—Kalning of Dorpat has prepared a similar extract from cultures of bacillus mallei. It goes by the name of **Mallein.** It is sent out from the Pasteur Institute in two forms. In the first the mallein is dilute, and has the appearance of a pale transparent straw-coloured liquid. This retains its activity for about a fortnight if the tubes in which it is contained are kept in the dark and unopened. The second is concentrated mallein, a thicker deeper-coloured liquid. Before use it must be diluted by adding nine times its volume of a ½ per cent solution of carbolic acid in water. The prescribed dose (Hunting and M'Fadyean, No. 445, v. 1892, p. 316) for a horse is 2½ c.c., and the best seat for injection the middle of the side of the neck.

When injected into a glandered horse it causes a marked rise of temperature. In an animal with an initial temperature, for instance of 101° F., it rose to 105° F. In a healthy animal the rise in temperature, if any, is almost imperceptible. Hence it has been considerably employed in the diagnosis of obscure and suspected glanders disease.

As in the case of tuberculin, it causes considerable local reaction. The glanders swellings sometimes become still more swollen, and in nearly all instances painful. When pure, it never confers the disease itself.

Finger asserted (No. 492, vi. 1889, p. 375) that he had rendered the cat and dog immune to glanders by repeated subcutaneous injection of sterilised glanders cultures.

7. **Anthrax.**—Hoffa (No. 634) obtained small quantities of a ptomaïne which proved toxic to frogs, rabbits, and guinea-pigs, from pure cultures of anthrax in meat broth. A proteid, an albumose, was isolated by Hankin (No. 6, 1889, ii. p. 810; *Ibid.*, 1890, ii. p. 65; No. 59, 1891, ii. p. 339), and Martin (No. 161, 1889-90, p. 235; also *Ibid.*, 1890-91, p. 255) found two such bodies which he says resemble

the proto- and the deutero-albumose of peptic digestion. Martin asserts that the chemical products formed by the bacillus inside the body of an animal made the subject of anthrax are the same as those produced by the bacillus outside the animal body, namely, anthrax proto- and deutero-albumose and a specific base provisionally called an alkaloid. It is the alkaloid which causes death. The large amount of it found in the tissues of the sheep compared with the amount of albumoses demonstrates this.

In a later communication (No. 6, 1892, i. p. 641) he says the anthrax alkaloid is an amorphous yellow body, with alkaline reaction, soluble in alcohol and precipitated by many reagents which throw down alkaloids, but not by Mayer's solution.

The following table drawn up by Vaughan and Novy (No. 630, p. 278) gives a synopsis of the bodies of the basic class which as yet have been isolated or which are presumed to exist in bacterial poisonous secretions :—

TABLE OF PTOMAÏNES.

Formula.	Name.	Discoverer.	Physiological action.[1]
CH_5N	Methylamine	Bocklisch	Non-poisonous
C_2H_7N	Dimethylamine	Brieger	,,
C_3H_9N	Trimethylamine	Dessaignes	,,
C_2H_5N	Spermine (?)	Kunz	,,
C_2H_7N	Ethylamine	Hesse	,,
$C_4H_{11}N$	Diethylamine	Bocklisch	,,
$C_6H_{15}N$	Triethylamine	Brieger	,,
C_3H_9N	Propylamine	,,	
$C_4H_{11}N$	Butylamine	Gautier and Mourgues	Poisonous (?)
$C_5H_{11}N$ (?)	Tetanotoxine	Brieger	,,
$C_5H_{13}N$	Amylamine	Hesse	,,
$C_6H_{15}N$	Hexylamine	,,	,,
$C_7H_{11}N$	Dihydrolutidine	Gautier and Mourgues	,,
$C_8H_{11}N$	Collidine (?)	Nencki	
$C_8H_{11}N$	Pyridine base (?)	O. de Coninck	
$C_8H_{13}N$	Hydrocollidine (?)	Gautier and Etard	Poisonous
$C_9H_{13}N$	Parvoline (?)	,, ,, ,,	
$C_{10}H_{15}N$	Unnamed	Guareschi and Mosso	Poisonous
$C_{10}H_{15}N$	Pyridine base (?)	O. de Coninck	
$C_{10}H_{17}N$	Hydrocoridine (?)	Griffiths	
$C_{32}H_{31}N$	Unnamed	Delézinier	
$C_2H_8N_2$	Ethylidenediamine (?)	Brieger	Poisonous
$C_3H_8N_2$	Trimethylenediamine (?)	,,	,,
$C_4H_{12}N_2$	Putrescine	,,	Not very poisonous
$C_5H_{14}N_2$	Cadaverine	,,	,, ,, ,,
$C_5H_{14}N_2$	Neuridine	,,	Non-poisonous
$C_5H_{14}N_2$	Saprine	,,	,,
$C_7H_{10}N_2$	Unnamed	Morin	,,
$C_{10}H_{26}N_2$ (?)	Susotoxine	Novy	Poisonous
$C_2H_7N_3$	Methylguanidine	Brieger	,,
$C_{19}H_{27}N_3$	Morrhuine	Gautier and Mourgues	Diuretic, etc.
$C_{13}H_{20}N_4$	Unnamed	Oser	
$C_{17}H_{38}N_4$	,,	Gautier and Etard	
$C_{25}H_{32}N_4$	Aselline	Gautier and Mourgues	Poisonous
$C_5H_{13}NO$	Neurine	Brieger	,,
$C_8H_{11}NO$	Mydine	,,	Non-poisonous

---

[1] Only those bases are here denoted as poisonous which possess a decided toxicity.

Formula.	Name.	Discoverer.	Physiological action.
$C_5H_{11}NO_2$	S-amidovalerianic acid	E. and H. Salkowski	Non-poisonous
$C_5H_{15}NO_2$	Choline	Brieger	Poisonous
$C_6H_{13}NO_2$	Mydatoxine	,,	,,
$C_6H_{13}NO_2$	Unnamed	,, 1888 (tetanus cult)	Non-poisonous
$C_6H_{15}NO_2$	Mytilotoxine	,,	Poisonous
$C_7H_{17}NO_2$	Gadinine	,,	,,
$C_7H_{17}NO_2$	Typhotoxine	,,	,,
$C_7H_{17}NO_2$	Unnamed	,,	,,
$C_{14}H_{14}NO_2$	Pyocyanine	Ledderhose	Non-poisonous
$C_5H_{13}NO_3$	Betaine	Brieger	,,
$C_5H_{15}NO_3$	Muscarine	,,	Poisonous
$C_9H_{13}NO_3$	Morrhuic acid	Gautier and Mourgues	
$C_5H_{12}N_2O_4$	Unnamed	Pouchet	Poisonous
$C_{13}H_{30}N_2O_4$	Tetanine	Brieger	,,
$C_{14}H_{20}N_2O_4$	Unnamed	Guareschi	
$C_7H_{18}N_2O_6$	,,	Pouchet	Poisonous
	,,	,,	,,
	Tryotoxicon	Vaughan	,,
	Mydaleine	Brieger	,,
	Spasmotoxine	,,	,,
	A diamine (?)	,, (tetanus cult)	,,
	Peptotoxine	,,	,,
	Phlogosine	Leber	Inflammatory

Leucomaines (λεύχωμα, *white of egg*).

1122. The term was applied by Gautier (No. 628) to *all those organic bases formed in the body during life and in the course of natural metabolism.* They are closely allied to the ptomaïnes. Many of them have been known as abstract excrementitious substances. Our knowledge of their relationship to the bacterial alkaloidal bases is a matter of later development.

They are divided into (1) the Uric acid group, and (2) the Creatinine group. According to Vaughan and Novy (No. 630, p. 282), the members of the first group are the following:—

Adenine	$C_5H_5N_5$
Hypoxanthine . . .	$C_5H_4N_4O$
Guanine	$C_5H_5N_5O$
Xanthine	$C_5H_4N_4O_2$
(Uric acid	$C_5H_4N_4O_3$)
Heteroxanthine . . .	$C_6H_6N_4O_2$
Paraxanthine . . .	$C_7H_8N_4O_2$
Carnine	$C_7H_8N_4O_3$
Pseudoxanthine . . .	$C_4H_5N_4O$
Gerontine	$C_5H_{14}N_2$
Spermine	C_2H_5N (?)

Those of the second group have all been discovered by Gautier (No. 635), and are regarded by him as allied to creatine and creatinine.

(Creatinine	$C_4H_7N_3O$)
(Creatine	$C_4H_9N_3O_2$)
Cruso-creatinine . . .	$C_5H_8N_4O$
Xantho-creatinine . . .	$C_5H_{10}N_4O$
Amphi-creatine . . .	$C_9H_{19}N_7O_4$
Base	$C_{11}H_{24}N_{10}O_5$
Base	$C_{12}H_{25}N_{11}O_5$

II. *The Bacterial Enzymes or Ferments.*

1123. Besides the gastric and pancreatic ferments of animals which transform proteids into compounds which are soluble and diffusible, there are certain bodies developed by plant life possessed of the same properties. Thus from Carica papaya the ferment papain is derived, which exerts a digestive action on proteids analogous to that of trypsin.

Such enzymes or ferments are also formed in many cases by the mycetes, and they have not only proteolytic, but also diastatic properties. The liquefaction of gelatine, which is so evident a property of this class of bodies, is due to the presence of such an enzyme. They act in an alkaline solution, and the quantity and character of the enzyme secreted varies with the soil on which the organism is grown. The spirillum of Asiatic cholera, for example, secretes a peptonising ferment in weak peptonised meat juice, a diastatic ferment in strongly nutritive solutions.

These enzymes can be extracted with glycerine.

Fermi (No. 476, x. p. 1 ; *also*, No. 629, v. 1892, p. 481) has made the enzymes which dissolve gelatine and fibrin matter of special study. Among other characteristics he finds that attempts to isolate enzymes in general from the protein bodies with which they happen to be mixed are unsuccessful. A temperature ranging between 50° and 70° C. destroys them when they are moist. When dry they will withstand a high temperature (140°-160° C.) better than the spores. They do not dialyse as the well-known enzymes pepsin, trypsin, and invertin do. They are active, as a rule, in nitrogen, carbonic acid, carbonic oxide, hydrogen, and sulphuretted hydrogen. Those of M. prodigiosus, B. pyocyaneus, and Koch's vibrio are affected prejudicially by sulphuretted hydrogen. Only a few bacterial ferments act upon fibrin ; they are powerless in dissolving egg albumin or casein. He has failed to find an organism which forms a fibrin-dissolving ferment in presence of an acid. This, however, is not to be wondered at when one reflects that all known micro-organisms, with the exception of some yeasts and moulds, as well as the different kinds of animal cells, if we exclude the secreting cells of the stomach, can live only in alkaline or neutral media.

The ferment-forming bacteria shed their ferments into dissolved and undissolved, peptonised and simple albumin. Less ferment is produced upon beef-tea than upon nutritive gelatine.

He supposes that these ferments do not exert a deleterious influence within the living body. They have nothing in common with toxines; toxines are crystallisable and soluble in alcohol. The difference between them is also borne out by the fact that many of those bacteria which secrete toxines do not secrete enzymes, and *vice versâ*. Thus out of 141 well-known toxin-secreting, that is to say, pathogenic organisms, he found only 26 which secreted an enzyme, and of 134 which are ferment-secreting, only 25 which also secreted toxines. These enzymes can be injected into the system of the mouse and rabbit with impunity; after twenty-four hours no trace of them is to be found. They resist the action of carbolic acid and corrosive sublimate better than spores.

III. *The Bacterial Albumoses or Tox-Albumins.*

1124. If certain bacilli such as that of anthrax are grown on a medium resembling in composition the liquids and solids of the body (animal proteid and mineral salts) they throw out an enzyme which digests the proteids with the formation of products resembling those of peptic and tryptic digestion. There is this difference, however, between the two (S. Martin, No. 6, 1892, i. p. 641), namely, that the final result in the case of the bacterial action is a basic body, a ptomaïn. Thus:—

Primary Agent or Primary Infective Agent.	Ferment.	Digestive Products.
Living cell.	Pepsin.	Syntonin; hetero-albumose; proto-albumose; deutero-albumose; peptone.
Living cell.	Trypsin.	Globulin-like body; tryptone (peptone); leucin; tyrosine; a bitter body.
Bacillus anthracis	(Anthrax digestion).	Hetero-albumose; proto-albumose; deutero-albumose; peptone; leucin; tyrosine; alkaloid (base).

Albumoses, as the table shows, are among these products. They constitute the most virulent of poisons, and are identical with the venom of poisonous snakes. One very active albumose is secreted by the anthrax bacillus, others are found in organs taken from cases of diphtheria, etc. (pp. 20, 26).

Literature on Bacterial Poisons.—**Aitken**: On the Animal Alkaloids, 1889. **Anderson** (Fermentation and Ptomaïnes): Gaillard's M. J. N. Y., xlii. 1886, p. 234;

Ibid., xliv. 1887, p. 325. **Arloing** (Anthrax): Compt. rend. Acad. d. sc., cxiv. 1892, p. 1521. **Arnaud and Charrin** (Microbal Secretions): Compt. rend. Soc. de biol., iv. 1892, p. 495. **Baginsky and Stadthagen** (Poisonous Products of Intestinal Micro-organisms): Berl. klin. Wochnschr., xxvii. 1890, p. 294. **Bouchard** (Intestinal Origin of Alkaloids): Rev. d. Med., Oct. 10, 1882. **Brieger:** Ueber Ptomaïne, 1885; *also*, Weitere Untersuchungen über Ptomaïne, 1885; *also*, Arch. f. path. Anat., cxv. 1889, p. 483; *also* (Peptotoxin), Deut. Med. Wochnschr., xvii. 1891, p. 917. **Brieger and Fraenkel:** Berl. klin. Wochnschr., xxvii. 1890, pp. 241, 268. **Brown:** The Animal Alkaloids, 1889. **Buchner:** Berl. klin. Wochnschr., xxvii. 1890, p. 673. **Charrin** (Toxines and Cellular Lesions): Compt. rend. Soc. de biol., v. 1893, p. 521. **Dieckerhoff and Lothes** (Mallein): Berl. thierärztl. Wochnschr., vii. 1891, p. 427. **Discussion:** Rev. méd. de Toulouse, xx. 1886, p. 498. **Emmerich** (Bactericidal Action of Blood-Serum): Centralbl. f. Bakteriol. u. Parasitenkrank., xii. 1892, p. 364. **Fermi** (Tryptic Enzymes): Centralbl. f. Bakteriol. u. Parasitenk., x. 1891, p. 401; *also* (Tryptic Enzyme of Bacteria), Centralbl. f. Physiol., v. 1891-92, p. 481; *also*, Arch. f. Hyg., xiv. 1892, p. 1. **Frankland** (Micro-organisms and Chemical Change): Nature, xlvi. 1892, p. 135. **Gamaleia** (Chemical Nature): Méd. mod., iii. 1892, p. 537. **Hankin and Wesbrook** (the Albumoses and Toxalbumins secreted by the Anthrax Bac.): Ann. de l'Inst. Pasteur, vi. 1892, p. 633. **Hunter** (Influence of O. on Formation of Ptomaïnes): Proc. Roy. Soc., xlix. 1891, p. 376. **Jeannel** (in Septicæmia): Rev. d. Chir., v. 1885, p. 360. **Kramer:** Med. News Phila., lxi. 1892, p. 543. **Macfadyen:** Rep. Med. Off. Loc. Gov. Bd., 1888, Lond., xviii. 1889, p. 481; *also* (Action of Enzymes produced by Bacteria), Journ. Anat. and Physiol., xxvi. 1891-92, p. 409. **Malerba** (Gliscrobacterium formed mucous subce.): Ztschr. f. physiol. Chem., xv. 1890-91, p. 539. **Martin:** Brit. Med. Journ., 1892, i. p. 641 *et seq.* **Nencki:** Ueber die Zersetzung d. Gelatine u. d. Eiweisses, 1876. **Perdrix** (Transformation of Azotised Principles in Cultures): Annales de l'Institut Pasteur, ii. 1888, p. 354. **Petruschky** (Bacterio-chemical Researches): Centralbl. f. Bacteriol. u. Parasitenk., vi. 1889, pp. 625, 657. **Pouchet** (from Koch's Bacillus): Compt. Rend. Acad. d. Sc., ci. 1885, p. 510. **Pregl** (a new Carbol-Methylene Blue Method): Centralbl. f. Bakteriol. u. Parasitenkrank., x. 1891, p. 826. **Rodet** (Toxicity of Products of Staphylococcus Pyogenes): Compt. rend. Soc. de biol., iv. 1892, p. 46. **Roger** (Toxicity of Extracts of Normal Tissues): Compt. rend. Soc. de biol., iii. 1891, p. 727; *also* (Toxicity of Products of Bac. Coli Comm.), Arch. de physiol. norm. et path., v. 1893, p. 499. **Roos** [Diamines (Ptomaïnes) in Cholera]: Berl. klin. Wochnschr., xxx. 1893, p. 354. **Schwalbe:** Deut. med. Wochnschr., xvi. 1890, p. 807. **Vaughan and Novy:** Ptomaines, Leucomaines, etc., 1891. **Wooldridge** (Mode of Action of Pathogenic Organisms): Rep. Local Gov. Board, Lond., xv. 1885, p. 151. **Wortmann** (Diastatic Ferment of Bacteria): Ztschr. f. Physiol. Chem., vi. 1882, p. 287.

PRESENCE OF INDOL IN CULTURES.

1125. The presence of indol in the media upon which an organism is growing is an important guide to its identification.[1] Its presence is indicated by a mineral (nitric) acid, giving more or less of a red reaction; or what is preferable, by the following test: To 10 c.c. of the culture liquid add 1 c.c. of a solution of nitrate of potash (2 centigrammes to the 100 grms. water), and then treat with a few drops of pure sulphuric acid. If indol is present the liquid colours from a rose tint to a deep red colour. Kitasato (No. 366, vii. 1889, p. 515) finds that the media on which the undernoted organisms are grown give the reaction—

Spirillum of cholera.
Bacterium of fowl cholera.

---

[1] See *Cholera*, p. 551.

Bacillus of septicæmia of rabbit.
Bacillus of swine cholera.
Bacillus of tetanus.
Bacillus of symptomatic anthrax.
Septic vibrio.
Finkler's spirillum.
Bacillus lactis.

NITRIFICATION—REDUCTION OF NITRATES—AND ABSORPTION OF FREE NITROGEN.

1126. **Nitrification.**—Nitric acid is generally admitted to be one of the most important plant foods in the soil. The quantity of it to be found in the soil, however, is comparatively small. This is said to be due to its being so readily absorbed by plant life, and to its being easily washed away. Soil converts the nitrogen of organic substances into nitric acid. As shown by Schlœsing and Müntz, this power is dependent upon the microbes in the soil, for when those naturally present within it are destroyed by antiseptics or otherwise, the soil loses this property.

According to Frankland (No. 636, xlvi. 1892, p. 136), there are two kinds of nitrifying bacteria, namely, (1) those which produce nitrous acid, and (2) those which transform this into nitric acid. The first set converts ammonia into nitrous acid, the second set carries this a step further. The members of the second set have no influence over ammonia.

Winogradsky's experiments go to show that these nitrifying bacteria can take up nourishment, multiply, and form protoplasm from a solution destitute of organic matter. It was held formerly that this was exclusively a property of organisms which contained chlorophyll. They further refuse to grow on ordinary solid culture media, but Kühne has overcome this difficulty by employing entirely mineral ingredients converted into a jelly-like consistence by silica[1] (Frankland).

Reduction.—Laurent (No. 423, iv. 1890, p. 722) finds that germinating seeds of different kinds, the tubers of potato, and several fruits have the power of reducing nitrates. He supposes that this property in the higher plants is due to a substance contained in them, and shows that it continues even if the vitality of the plant is destroyed. Similar properties are possessed by algæ and fungi, and in a high degree by bacteria. Yeasts do not manifest this function to any marked extent.

Dehérain and Maquenne, Gayon and Dupetit, Frankland and Warrington, more especially the last two, have shown that a large number of bacteria can also reduce nitrates, and Laurent has confirmed their observations. There is this difference, however, between the action of bacteria and such substances as the tuber of potato, namely, that if the vitality of the bacteria is destroyed there is never any production of nitrites.

---

[1] Ammonium sulphate, potassium phosphate, magnesium sulphate, calcium chloride, magnesium carbonate, and dialysed silicic acid.

The nitrites disappear when the medium becomes acid, and this disappearance can be prevented by the addition of a little carbonate of lime. Acids destroy nitrites when formed from any source.

Absorption of Free Nitrogen.—Plants were until comparatively lately supposed to gain their nitrogen always from that element in combination. The question has often been asked whether there was any evidence of their absorbing the nitrogen which is free in the atmosphere directly into their substance, and always until lately answered in the negative. The works of Frank, Hellriegel, and Wilfarth, Lawes, Berthelot, Gilbert and Pugh, Schlœsing and Laurent, and others, have demonstrated not only that this is a possibility, but that with certain legumes and green plants low in the scale it takes place freely.

Upon the roots of certain legumes (pea) there are to be found tuberosities, whose purpose heretofore had always been more or less of a mystery. Recent investigation has gone to prove beyond a doubt that they are organs for the absorption of free nitrogen. They swarm with bacteria, and apparently it is through their instrumentality that the absorption is effected. By them it is passed into the substance proper of the plant.

These bacteria, according to Berthelot (No. 40, cxvi. 1893, p. 842), can also abstract their nitrogen from organic compounds, and will do so by preference if they are freely supplied with it in that form. Indeed, they flourish best on such a basis. It is only when they are forced to do so that they abstract it from the atmosphere.

IMMUNITY.

1127. Probably from the remotest times it has been a matter of common observation that, in a large majority of the infectious fevers, the afflicted individual, after recovery, enjoys a more or less complete immunity from a future attack. The acquired immunity lasts from a few months up to the remainder of a lifetime. The period varies according to the disease and the idiosyncrasy of the individual. Thus an attack of measles in childhood may fairly be supposed to exempt the subject of it from a second attack, and this holds good as well of scarlet fever, typhoid, typhus, and practically also of smallpox.

The same may be asserted of most of the contagious diseases—that is to say, those diseases conveyed by actual contact, not through the intermediation of the atmosphere. In fact, the presumption is legitimate that they all come under this category, with the qualification that the truce enjoyed varies in point of duration.

But there is another equally well-recognised fact bearing upon this subject, namely, that certain species of animals are protected naturally against infectious and contagious disease to which others of near kinship fall a prey. Many of the diseases of this class having their stronghold in the system of Man are unknown as diseases of the lower animals, and contrariwise. The ordinary sheep takes anthrax readily, but it is with the greatest difficulty that the disease can be inoculated upon the Algerian sheep. There is no animal to which anthrax can be conferred so readily as the mouse, yet the adult rat is almost quite immune. Tubercle is a disease practically unknown in the ordinary sheep, yet the cow is very susceptible to it.

What this acquired and this natural immunity are dependent upon has remained till recently a complete mystery. We cannot be said even yet to have a thorough knowledge of how it comes about, but a good deal of information has lately been acquired.

Vaccines.—Various attempts were made upon purely empirical grounds, in bygone times, to protect the system from infectious and contagious disorders, in none with more success than in the case of the adoption of **vaccination against the smallpox.** Still we have no conception how vaccination acts in bringing about this desirable state of body. We are not even agreed about the relationship of cow-pox to smallpox. Numerous as have been the endeavours to confer smallpox upon the cow, it cannot be said that any one of these has been attended with success. There are thus some grounds for affirming that the two diseases are essentially different, although so far related that the one acts as a protection against the other.

Vaccination with the Microbe.—The earliest attempts to prepare vaccines (*sic*) artificially were directed to attenuating the virulency of the microbes which are the cause of contagion, with the purpose in view of utilising these for inoculation purposes. The fact that a disease microbe may exist with various degrees of virulency, and that, when in an attenuated condition, it may still act as a protective, was first demonstrated by Pasteur. In a note to the French Academy he described how the virus of fowl cholera, a peculiarly destructive malady prevailing in the poultry yards around Paris, can be attenuated by long exposure of an artificial growth of the organism to air. It becomes so diluted that perhaps only one in ten animals dies when infected by it, and a stage is at length reached in which the virus does not kill, but nevertheless plays the part of a vaccine. He assumed that the attenuating agent was the prolonged contact with the atmosphere.

Similar experiments, as already detailed, were made with anthrax (vol. i. p. 141). Since then it has been found that most pathogenic organisms become attenuated when grown out of their natural habitat, and some of these in their diluted condition have been employed as vaccines. Tubercle is an exception to this general statement. It is apparently as virulent after being grown for a succession of generations as it was when removed from the original host.

Chemical Vaccination.—Later on, however, another method of vaccinating was introduced, namely, that of employing the products elaborated by the microbe rather than the microbe itself. It is known as *chemical vaccination* in contrast to that just described, which is usually termed *vaccination with the microbe.*

The general results of this method bear out that, in order to render an animal immune against a particular contagious malady, it is unnecessary to employ the microbe itself. The chemical products are sufficient to procure the desired end. The procedure, in addition, is one fraught with less danger, although the immunity in most cases is not so lasting as when the microbe itself is used. Vaccination with the microbe is always attended by the difficulty that the organism may have reassumed a state of virulency.

Separation of the Chemical Products.—The means adopted for separating the chemical products from the organism are various. Among the earliest was that of filtration through porcelain. Heating up to a high temperature has also been employed, but the procedure may destroy the vitality of the microbes only partially, and is also liable to injure the chemical substances it is desired to retain.

A procedure which, in the hands of Roux and de Christmas, has proved most serviceable is the mixing of certain essences, such as those of garlic, mustard, or eucalyptus, with the infected blood or artificial culture. These essences are powerful germicides, but leave the chemical products unimpaired. They are likewise volatile, and consequently after having served their purpose can be got rid of readily by evaporating *in vacuo.* Anthrax blood thus treated is rendered harmless as a means of conveying the disease, but nevertheless its introduction into the system of an animal like the sheep confers an immunity more or less durable.

Chemical Vaccination against Tetanus.—Some of the most remarkable experiments bearing upon the subject of chemical vaccination have been made with tetanus. This disease is particularly well suited for the purpose, for, like diphtheria, the bacillus lives only locally in the wound; it is not disseminated broadcast throughout the blood and tissues. The toxic symptoms are due to the absorption of the tetanic toxines secreted in the part upon which the tetanus bacillus has taken hold.

By the use of oft-repeated doses of the filtered chemical products or toxines of a growth of the tetanus bacillus the system gradually becomes inured to their action, so that a dose of toxine far beyond that which otherwise would be lethal for the animal experimented upon can be borne in time by it with impunity. Thus Roux and Vaillard (No. 423, vii. 1893, p. 65) find that they can inject 3 c.c. of a tetanic toxine solution on the first day, 5 c.c. on the fifth day, and 12 c.c. on the ninth day; and so on, it is said, up to a matter of 100-120 c.c., always allowing an interval of eight days between each of the later injections.

Immunisation by Antitoxic Serum.—When this stage of tolerance of the tetanic toxine has been reached a new feature is observed, namely, that the serum of the animal so immunised has the power of conferring this immunity upon a fresh host when introduced into its circulation. The explanation usually given of this power is that the presence of the toxine in the blood has called forth the formation of a substance which is inimical to it, which destroys or neutralises it, and to which accordingly the name "antitoxine" has been applied. Its source is supposed to be the cells, probably the fixed cells, of the tissues. The properties of the serum of the blood of an animal so immunised against tetanus are very remarkable. If equal parts of such serum and of tetanic toxine sufficient to kill a guinea-pig be mixed and introduced into the system of a fresh guinea-pig, the animal does not manifest any sign of tetanus. Supposing that 120 c.c. of a filtered tetanic culture be injected into a vein of the ear of the rabbit previously rendered immune, the blood withdrawn thirty minutes afterwards is found to be free from toxic properties even when introduced into the system of an animal so sensitive as the mouse. It nevertheless confers immunity upon the recipient. And the more toxine employed, provided sufficient time has been allowed to elapse after its introduction, the more antitoxic the serum seems to become. It is easy to obtain serums whose protective power in this way is extraordinary. The immunising power of such serum continues, according to Roux and Vaillard, for years, but becomes gradually weaker and weaker. The action of the antitoxine upon the toxine is instantaneous. The moment the mixture is made it becomes innocuous. And this happens irrespective of whether the mixture is conducted *in vitro* or in the blood circulating in the body of the experimental host. If, for instance, a deadly dose of toxine be injected into the cellular tissue of one flank of an animal and an equivalent dose of antitoxic serum into the other, the animal, owing to the unequal power of diffusion of the two substances, may suffer for a time from tetanic symptoms, but these rapidly disappear, unless it be at the point where the toxine has been injected.

Immunity seems to be acquired immediately after the introduction of a single large dose of antitoxic serum, and is proportional to its strength, but this form of immunity is far less lasting than that acquired gradually by the introduction of successive small doses of toxine or by the inoculation of an actual culture of the tetanus microbe. Each time that the cells of the organism are subjected to the action of the tetanic toxine they fortify themselves for a certain period against its influence, and the period seems to be proportional to the number and strength of the doses employed. This would tend to show that while antitoxic blood-serum acts simply upon the blood, owes its action, in fact, to its antidotal properties, and is proportional to the quantity introduced, the repeated introduction of toxine effects some permanent influence upon the cells of the body which presumably secrete the antitoxine. Such a supposition is borne out by the fact that frequent depletions of blood have very little influence upon the antitoxic powers of the serum of the blood of an animal rendered immune by repeated introduction into its circulation of diluted toxine.

Contrary to what might be expected, the blood of animals naturally immune to tetanus, such as the fowl, has no antitoxic properties. Yet their blood can be rendered antitoxic, like that of other animals, by the introduction of a dose of tetanic toxine. The immunity enjoyed by such animals in all probability is not owing to the naturally antitoxic properties of the blood, but is due to some as yet unrevealed circumstance. The question of the mode of formation of the antitoxic substance is one of much interest. In the case of tetanus it seems to be formed only upon occasion, and in accordance with the amount of tetanic toxine introduced. Is it merely a modification of this toxine, or is it a new secretion? We know that it exists in the serum alone; the blood-clot is free from it; while other serous liquids and the liquid excreta throughout the body show it in various degrees of concentration. The milk is rich in it; milk acts, indeed, like blood-serum as an immunising agent. For if the suckling mother is rendered immune she is capable of conferring her immunity to the offspring through the milk. One of the most plausible explanations is that the antitoxine is secreted by special glands, such as the thymus, thyroid, or spleen. It is difficult to isolate these glands in the living body, and hence to say in how far any positive result is due to them. It has been asserted by Brieger, Kitasato, and Wassermann that extract of the thymus gland has a powerfully antitoxic action over the toxines of tetanus, diphtheria, typhoid, etc. Another supposition is that it is secreted by the leucocytes of the blood. But it cannot be said that we have as yet any definite or distinct notion of where it is derived from.

Seeing that antitoxic serum has so powerful an inhibitory influence on the development of tetanus, one would naturally be anxious to know whether it exerts a curative action upon the disease when once thoroughly established. In this direction success as yet has been only partial. By the time the first symptoms show themselves the tetanic toxine has had an opportunity of acting upon the cells throughout the body, and the antitoxine cannot do anything to counteract the poisoning of their protoplasm, which has been already accomplished. Doses of the strongest serum are ineffectual against tetanus when thoroughly established, and this holds good both in the case of the lower animals and in that of Man.

Antitoxine from Glands.—As bearing upon the supposed origin of the antitoxine of tetanus from the fixed cells of the body, it may be mentioned that attempts have been made by Brieger, Kitasato, and Wassermann to prepare it artificially from certain glands such as the thymus. They conclude that from particular organs of healthy animals certain antitoxic substances can be obtained which are inimical to the toxines secreted by various microbes such as those of tetanus, cholera, diphtheria, typhoid, erysipelas, swine fever, and anthrax.

Healthy Blood-Serum Germicidal.—Indeed, healthy blood-serum appears to be germicidal in a high degree, for, as the experiments of Nuttal (1888) went to show, and as those of Hankin, Buchner, and Roux confirmed, organisms such as that of anthrax are killed in large percentage when suspended in it. In half an hour after mixing anthrax bacilli with freshly-defibrinated blood, a great number of them will be found to have perished. It does not, however, prove fatal to the whole of them. The remainder, if left, may continue to grow. The blood, or its serum, in time loses this property completely, so that, as is well known, it comes to constitute one of the best of culture media.

There is thus evidently something dissolved in the blood-serum which is antidotal to the toxines of anthrax and, it may be, other microbes. What then is this? Hankin and Buchner have succeeded in separating proteid substances, what the former calls "defensive proteids," the latter alexines (ἀλέξω, I defend), which they allege are the agent in question. Hankin has derived them not only from the blood, but also from the spleen and lymphatic glands, and both he and Buchner are agreed that they result from the metabolism of different cells throughout the body. They are freely soluble in glycerine, although not in alcohol or ether.

Vaccination against Cholera.

Haffkine's method of anticholeraic vaccination (see No. 6, 1893, i. p. 227) is founded on the principle of calling forth an excess of these defensive proteids, or whatever they may be, by the subcutaneous injection of an extremely virulent culture of the cholera spirillum or of this sterilised by the addition of a little carbolic acid. The former is the more powerful agent, but it is also necessarily the more dangerous of the two.

The organism as taken from the intestine of a cholera patient is not sufficiently virulent. Its power requires to be exalted by cultivation in the peritoneal cavities of a succession of guinea-pigs up till a time when it is so intense that it destroys the guinea-pig a few hours after its introduction into the peritoneum. In order to make sure that no contamination has occurred in the successive transferences from one animal to another, some of the growth from the last guinea-pig is sown on an agar plate, and a fresh culture on an agar tube is made from a pure colony. After this has grown for some time, some sterilised beef-tea is introduced into the tube, and shaken up with the organism. This constitutes the vaccinating liquid, and may be used as it is (living vaccine), or, as before mentioned, after the addition of a little carbolic acid.

Pasteur's Method of Prophylaxis against Hydrophobia.

1128. One of the chief characteristics of rabies in the rabbit as compared with the disease in Man is the short period of its incubation. If the rabic virus, moreover, be inoculated on a series of rabbits through a trepan opening in the skull, using the medulla of one animal as the means of inoculation of another, the period of incubation becomes progressively shorter and shorter. There comes a time, however, in which it is reduced to exactly six days, and when that is so the poison goes by the name of "virus fixe." If the cord from a rabbit suffering from rabies as a result of this "virus fixe" be suspended in an atmosphere dried by the presence of potash and kept at a temperature of 23° C. it gradually loses its virulence, so that after five to six days it fails to confer rabies upon animals even when inoculated on the dura mater.

It can still, however, be employed as a prophylactic. The drying of the cord as a means of reducing the virulence of the poison contained in it was suggested to Pasteur by his having observed that cords of rabbits dead for some time contained a virus of less strength than those which were fresh. According to the length of time the cord is exposed, so a series of viruses of graduated strength can be obtained. The cords containing the poison in different stages of attenuation are beat up with a little bouillon, and the liquid decanted off is the prophylactic. A few drops are injected subcutaneously by means of a sterile syringe.

In former times Pasteur used to begin the injections with the liquid from a cord exposed for fifteen days, and proceeded daily until a cord was reached which had been exposed for only twenty-four hours. As a result of further experimentation on dogs, he found that it is much better to begin with a cord of ten days' exposure, and to administer three injections daily. The cords used on the first day are exposed for ten, nine, and eight days respectively. On the second day of the treatment he employs cords of the seventh, sixth, and fifth days, and so on until the treatment is completed on the morning of the fourth day by a single injection taken from a cord exposed for twenty-four hours. This cord may be looked upon practically as fresh, seeing that the potash has had the effect simply of drying the cortical layers, while the centre remains unaltered. When this first course of treatment is over, he waits for a day or two, and then commences a second course, in which one injection daily is considered sufficient, but initiated with a spinal cord exposed only for seven days in the desiccating bottle.

Immunity to Ricin and Abrin.

1129. A most remarkable discovery has been made by Ehrlich (No. 93, 1891, No. xxxii.; *Ibid.*, No. xliv.; *also*, No. 49, 1891, i. p. 292), namely, that an immunity similar to that just described against tetanus can be acquired against the two substances *ricin* and *abrin*. They are described as tox-albumins. Ricin is obtained from the castor-oil seed (Ricinus communis); abrin is abstracted from the jequirity bean. Both are highly poisonous substances, ricin more so than abrin. It is estimated by Ehrlich that one gramme of ricin would suffice to kill one and a half millions of guinea-pigs. If it is injected under the skin it induces intense inflammation and caustic action. Hence, in order to immunise the animals experimented upon, he found it necessary to administer the ricin by the mouth. If repeated small but increasingly large doses are given to guinea-pigs by the mouth, there comes a time (twenty-one days) when they are able to withstand the action of the substance administered subcutaneously up, it is said, to four hundred times the lethal dose.

Abrin acts like ricin when injected subcutaneously, but not so actively. When introduced, however, into the conjunctival sac it induces intense panophthalmitis, often ending in destruction of the organ. After mice have been fed for some weeks with food containing abrin, the strongest application of the substance to the conjunctiva was without effect in setting up inflammation.

Ehrlich supposes that these effects are dependent upon a defensive substance present in increasing proportion in the blood, and to which he tentatively applies the name **antiabrin.** As bearing out this supposition he asserts that injection of the blood of animals rendered immune against ricin into the mouse and rabbit renders them also immune.

Essential Cause of Immunity.

1130. Facts such as these raise many curious questions as to what immunity consists in. Are we to conclude that for each toxine against which the system fortifies itself, there is secreted the appropriate antitoxine, or is there some wide general principle at work of which at present we have no knowledge ? It were needless waste of time to indulge in speculation on a subject where experimental proof alone is of value. There seems very good reason for believing that much more light will be shed on the matter before long.

Regional and Hereditary Immunity.

1131. The experiments of Bidenkap, Diday, and others have shown that, if a series of inoculations of **syphilis** are made in the skin of a person suffering from the syphilitic chancre, the parts become more sensitive to its action the further the point of inoculation is removed from the primary sore. In its immediate neighbourhood the inoculations induce merely an abortive papule, at a distance a true chancre. There is thus, as it were, a *regional immunity* in this first stage.

As the secondaries appear (eight to ten weeks) there follows an *absolute immunity.* The organism fails to react in any way to the syphilitic virus, and as the secondaries decline (during the following two years) absolute immunity, continuing for years (nineteen to twenty), is the rule, but not the invariable rule. Indeed, it is quite exceptional to find the individual twice infected by the syphilitic poison. This, however, may in a manner be accounted for by collateral causes such as advancing age.

Children hereditarily syphilitic appear to be immune, but exceptions even to this rule are said to have occurred. Children born healthy of parents who have had syphilis nevertheless appear to remain immune, or contract the disease in a mild form. The mother may remain uninfluenced while the children have acquired immunity.

Doctrine of Phagocytosis and Immunity.

1132. The experiments of Cohnheim (No. 13, xl. 1867, p. 1), Hoffmann and v. Recklinghausen (No. 50, v. 1867, p. 481), Hoffmann and Langerhans (No. 13, xlviii. 1869, p. 303), and in later times of Siebel (No. 13, civ. 1886, p. 514) have shown that when minute inorganic pigment particles such as cinnabar or indigo are introduced into the circulation they are seized upon within a few minutes by the leucocytes of the blood. Within twenty-four hours nearly the whole of the pigment-loaded leucocytes have vanished from the circulating blood and have taken up their stronghold in various organs of the body, more especially the spleen, bone, marrow, and lymphoid tissues generally. The cells forming the walls of the portal vein capillaries appear to absorb the particles directly from the blood circulating through them and become deeply loaded. Other fixed cells throughout the body also become pigmented, but they seem to derive the particles from extruded leucocytes.

Reference has already been made (vol. i. pp. 266, 293) to the part living cells take in the removal of effete tissues such as the larval tail and gills. They intussuscept the tissue débris into their protoplasm whose juices apparently digest it.

Similarly, when a pure culture of certain micro-organisms such as the tubercle bacillus is injected into the jugular vein of a rabbit, the leucocytes throughout the lung seem to have absorbed the whole of the bacilli within a matter of from ten minutes to fourteen hours. Their distribution in the leucocytes throughout the body is more general after a day. In the case of the tubercle bacillus the leucocytes which contain them all die and degenerate.

It does not necessarily follow, however, that the cell-host always dies. In many cases what happens is rather that the intussuscepted microbe perishes and becomes digested.

These observations have been utilised by Metchnikoff (see Bibliog.)

to explain the phenomena of immunity in opposition to the chemical theory just described.

The main facts of Metchnikoff's theory are briefly as follows (No. 6, 1891, i. p. 213):—When a micro-organism is found within a living cell, its passage thither has been effected by movements either on the part of the microbe or of the cell itself. The former method of transference is very rare, but there is evidence of its possibility in the fact of the parasites of malaria invading the hæmocytes of the blood. More commonly, however, the transference is effected by the movements of the cell protoplasm.

Cells which devour living or dead particles are known as **phagocytes,** and of such the amœbiform leucocyte of the blood and lymph is the most typical example. There are also cells, such, for instance, as those forming the endothelial lining of the blood-vessels, which differ from these in being fixed, but which nevertheless absorb foreign particles of different kinds with avidity. There are thus two classes of phagocyte, namely, fixed and free. Not all leucocytes appear to have a phagocytal action. Three main forms of leucocyte may be distinguished, namely: (1) the so-called **lymphocyte,** which is characterised by its small size, its large single nucleus, the small amount of surrounding protoplasm, and by the fact that it is immobile and not phagocytal. The remaining two forms are phagocytal, namely: (2) the large unicellular leucocyte or **macrophage,** whose nucleus is sometimes lobed or reniform, which stains well with aniline dyes, possesses much protoplasm, and is endowed with active amœboid movements; and (3) the **microphage,** a small form, also staining well, but either multinuclear or with one nucleus in process of breaking up.

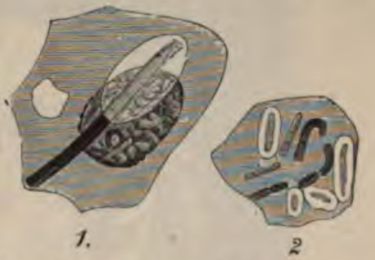


FIG. 574.—PHAGOCYTES, MACROPHAGE AND MICROPHAGE, TO SHOW STAGES OF DIGESTION AND DESTRUCTION OF BACILLI FROM SPLEEN AND EYE RESPECTIVELY OF WHITE RAT WITH ANTHRAX.

In *1* part of the bacillus is unaffected, but a vacuole has formed around the other part, which further has now lost the power of taking the stain. In *2* various stages are seen, the bacilli passing through that of granular faint staining to that of vacuolated unstained, until finally "shadows" are alone observable (Zeiss $\frac{1}{12}$, ocular 3; after Metchnikoff).

It may be affirmed, to begin with, that *the more malignant the micro-organism the rarer is its presence within the phagocytes.* Thus of all diseases, chicken cholera affecting birds and rabbits, hog cholera (cholera des porcs) given to pigeons and rabbits, the anthrax of mice and other specially sensitive animals, the septicémie vibrionenne of guinea-pigs and birds, run a peculiarly swift course, and in the whole of them it is quite exceptional to find the corresponding bacteria within cells. They remain free both at their point of introduction and when they gain access to the blood.

In those bacterial diseases which run a slow course, on the contrary, the bacteria are to be found either in part or wholly within the phagocytes. Thus tuberculosis, leprosy, rhinoscleroma, and glanders run a chronic course, and in all of them the specific bacteria are engulfed by phagocytes.

On inoculating an animal refractory to a particular microbe it is found that the parasite begins to develop, but that, from the onset, a reaction on the part of the organism shows itself, accompanied by a considerable emigration of leucocytes. These soon envelop the bacteria in great numbers. He explains the resistance of an animal rendered refractory artificially by the phagocytes having acquired the property of seizing upon and destroying the offending particles.

There is thus a natural enmity between phagocytes and microbes, and having come into actual conflict, the victory is usually on the side of the phagocyte.

It should be mentioned, however, that there are cases, such as that of the tubercle bacillus injected into the circulation, where the result is different, and where the protoplasm of the phagocyte falls to pieces and allows the included bacilli to escape. He looks upon the giant-cells of tuberculosis as huge phagocytes. The destruction of the tubercle bacilli can be distinctly traced within them. The bacilli swell, their enveloping membrane becomes much thickened and highly refractile, and in time the contents lose their power of fixing the staining material, so that, eventually, nothing is left of them but a conglomerate mass of slightly yellowish shadowy bodies.

The invasion of the organism by microbes induces most often an inflammatory reaction with its associated emigration of leucocytes. These leucocytes seize upon the invaders and destroy them, so that he is led to admit that the afflux of phagocytes to the invaded region and their bactericidal properties are mechanisms which serve to ward off bacterial attack and to maintain the integrity of the organism.

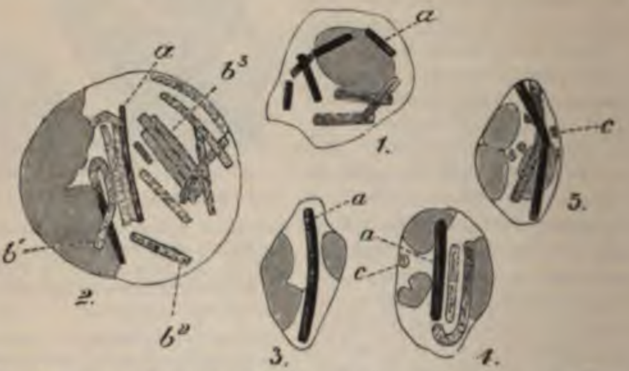


FIG. 575.—ANTHRAX OF PIGEON (AN ANIMAL BUT SLIGHTLY SUSCEPTIBLE TO THE DISEASE) TO SHOW STAGES OF DESTRUCTION OF BACILLI BY PHAGOCYTES.

(*1* and *2*) Macrophages: *1*, from exudation of eye from refractory bird; *2*, from muscle of region of inoculation of bird that succumbed; (*3*, *4*, *5*) microphages—all from eye twenty-seven hours after inoculation; (*a*, *a*) unaltered bacilli; (b^1, b^2, b^3) bacilli becoming more and more degenerated and indistinct; (*c*, *c*) débris of bacilli (Zeiss $\frac{1}{12}$, ocular 3; after Metchnikoff).

But it must be remembered that where the phagocytes appear upon the scene in relatively large numbers, and even include the micro-organisms, the latter gain the day whenever and wherever the phagocytes are incapable of destroying them or of preventing their growth.

Chimiotaxis.—In this war between the organism and bacteria an important part is played by the sensitiveness of the phagocytes to external influences, and especially to the chemical composition of their environment. The researches of Pfeffer (No. 640, i. p. 363) have shown that a solution of malic acid has the property of attracting the zoosperms of ferns, while saccharose has the same power over those of mosses.

Massart and Bordet allege that the poisonous products secreted by microbes exert a like attractive sway or "positive chimiotaxis" over leucocytes, a supposition which has been eagerly seized upon to account for the phenomena of microbal phagocytosis.

The substance secreted by bacteria which has this hidden property is said by Buchner to be a proteid, while Roux supposes it to be represented in the poisonous toxines secreted by the microbes. On the other hand, it has been found that certain agents, such as lactic acid, have a repellant or "negative chimiotactic" influence upon leucocytes.

When negative chimiotaxis manifests itself, the parasites, being shunned by the white corpuscles, freely propagate themselves, and induce the death of their host. Nevertheless, this chimiotaxis is not immutable, and the cells can become accustomed to substances from which they shrank at first. A negative may thus be transformed into a positive chimiotactic state. Such obtains in acquired immunity; the cells which in the unvaccinated animal never seized upon the bacteria now in the vaccinated take them up readily.

The experiments of Everard, Demoor, and Massart (No. 423, vii. 1893, p. 165), moreover, would go to show that the injection of microbic cultures, living or dead, tends to cause at first a decrease in the number of leucocytes circulating, and above all, of leucocytes with polymorphic nucleus and with protoplasmic granules. When the animal resists infection there follows a corresponding increase in their number, followed by a return to the normal. In an animal which succumbs to infection this hyperleucocytosis completely fails.

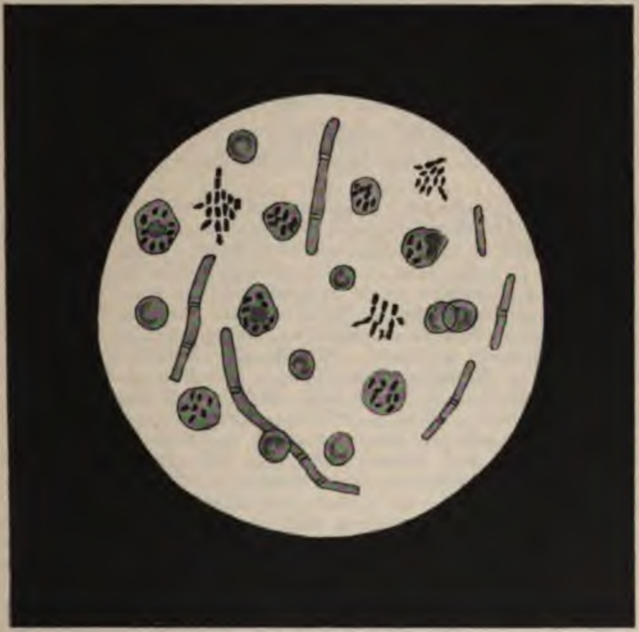


FIG. 576.—BLOOD OF MOUSE ILLUSTRATING PHAGOCYTOSIS (Beck $\frac{1}{12}$, homog. imm., Hartk., Oc. 4, upper tube out).

The animal was inoculated with anthrax, but did not die for some days afterwards. The blood contains two organisms—anthrax and a minute oblong rod. The oblong rod is being intussuscepted by the blood leucocytes (Gram's method).

The leucocytes of a vaccinated animal differ from those of a fresh animal not only in the education their chimiotactic faculties have undergone, but also in the rapidity of their development. They reach the adult state much sooner, and, arrived at this, are more apt in englobing microbes.

Such being a brief digest of the main facts of Metchnikoff's theory, it may be asked whether it is sufficient to account for immunity as we now understand it. Provided that all contagious diseases were due to the wide-spread personality of diseased microbes, there might be some show of reason for accepting it. But, as demonstrated of late, we can call forth all the symptoms of a disease like tetanus by introducing the secretions from its bacillus into the system, and what is even more remarkable, the system in course of time fortifies itself not against the actual bacillus, but against the toxines secreted by it. Moreover, the same condition of immunity may be excited against such purely chemical substances as ricin and abrin (p. 1002). This property of immunity, further, is resident in the blood-serum, and can be transferred from one host to another.

There are many objections to this phagocyte theory which must be got over before it can be accepted by those not wholly given over to a partisanship more or less blind to its many defects.

Literature on Immunity from Disease.—**Abbott:** Practitioner, xlvii. 1891, p. 415; *also* (Review), Med. News, Phila., lix. 1891, p. 534. **Ali-Cohen** (Chimiotaxis): Centralbl. f. Bakteriol. u. Parasitenk., viii. 1890, p. 161. **Arnold** (Fate of Wandering Cells): Arch. f. path. Anat., cxxxii. 1893, p. 502. **Bataillon:** Recherches anatomiques et expérimentales sur la métamorphose des amphibies anourés, 1891. **Baumgarten** (Phagocyte Doctrine): Beitr. z. path. Anat. u. z. allg. Path., vii. 1889, p. 3. **Behring:** Das Tetanusheilserum, 1892; *also* (Nature of Bodies conferring Immunity), Arch. f. Physiol., 1893, p. 381. **Bitter:** Ztschr. f. Hyg., iv. 1888, pp. 290, 318. **Bonaduce** (Blood-Serum and Natural I.): Beitr. z. path. Anat. u. z. allg. Path., xii. 1892-93, p. 353. **Brieger and Ehrlich** (Immunity conferred through the Milk): Deut. med. Wochnschr., xviii. ,1892, p. 393. **Brieger, Kitasato, and Wassermann:** Ztschr. f. Hyg. u. Infectionskrank., xii. 1892, p. 137. **Brunton:** Brit. Med. Journ., 1893, i. p. 10. **Brunton and Bokenham** (Influence of Mineral Constituents): Brit. Med. Journ., 1891, ii. p. 114. **Buchner:** Wien. med. Bl., xiv. 1891, p. 527 *et seq.*; *also* (Protective Substances of Serum), Berl. klin. Wochnschr., xxix. 1892, p. 449; *also* (New Standpoint of Immunity Question), Fortschr. d. Med., x. 1892, p. 319. **Capparelli** (Phagocyte Doctrine): Centralbl. f. Bakteriol. u. Parasitenk., x. 1891, p. 277. **Charrin** (Evolution of Microbes in Vaccinated Animal): Compt. rend. Soc. de biol., i. 1889, p. 627. **Charrin and Gley** (Hereditary Transmission of I.): Arch. de physiol. norm. et path., v. 1893, p. 75. **Charrin and Roger:** Compt. rend. Acad. d. sc., cix. 1889, p. 710. **Danilewsky** (Phagocytes): Ann. de l'Inst. Pasteur, iv. 1890, p. 432. **Discussion:** Brit. Med. Journ., 1892, i. p. 373. **Discussion on Phagocytosis and Immunity:** Trans. Path. Soc. Lond., xliii. 1891-92, p. 238. **Duclaux** (Intracellular Nutrition): Ann. de l'Inst. Pasteur, iii. 1889, p. 97. **Ehrlich** (Ricin and Abrin Immunity): Deut. med. Wochnschr., xvii. 1891, pp. 976, 1218; *also* (Immunity through the Milk), Ztschr. f. Hyg. u. Infectionskrank., xii. 1892, p. 183. **Emmerich:** München med. Wochnschr., xxxviii. 1891, p. 339. **Emmerich and Mastbaum:** Arch. f. Hyg., xii. 1891, p. 275. **Emmerich and Tsuboi** (Augmentation of Microbicidal Properties of Blood-Serum): Centralbl. f. Bakteriol. u. Parasitenkrank., xiii. 1893, p. 575. **Fodor** (Capability of the Blood to destroy Bacteria): Deut. med. Wochnschr., xiii. 1887, p. 745. **Gallemaerts** (Absorption of B. subtilis by Phagocytes): Bull. Acad. roy. de Méd. de Belg., 1887, i. p. 738. **Gostling** (Increase of Leucocytes of Blood in Inflammation): Brit. Med. J., 1886, i. p. 112; Med. Chir. Trans., Lond., lxix. 1886, p. 183. **Grawitz** (Part played by Leucocytes): Verhandl. d. x. internat. med. Cong., 1890, Berl., 1891, ii. 3 Ab., p. 9. **Hamer:** Rep. Med. Off. Loc. Gov. Bd., xx. 1891, p. 267. **Hankin:** Lancet, 1891, ii. p. 339; *also*, Tr. VII. Internat. Cong. Hyg. and Demog., 1891, Lond., 1892, ii. p. 145. **Hess:** Arch. f. path. Anat., cix. 1887, p. 365; *Ibid.*, cx. 1887, p. 313. **Jawein** (Cholera Immunity): Ann. de l'Inst. Pasteur, vi. 1892, p. 708.

Kanthack: Brit. Med. Journ., 1892, ii. p. 985. **Klein** (Phagocytosis): Nature, 1891; *also*, Centralbl. f. Bakteriol. u. Parasitenkrank., xi. 1892, p. 598; *also* (Inoculation of different Infections in same Animal), Rep. Local Gov. Bd., xxi. 1893, p. 135. **Klemperer** (Immunity and Cure): Berl. klin. Wochnschr., xxix. 1892, p. 293; *also* (Natural), Arch. f. exper. Path. u. Pharmakol., xxxi. 1892-93, p. 356. **Klemperer and F. Klemperer** (Immunity from Pneumococcus): Berl. klin. Wochnschr., xxviii. 1891, p. 833. **Kruse:** Beitr. z. path. Anat. u. z. allg. Path., xii. 1892-93, p. 333. **Lewek** (Influence of Non-Pathogenic Organisms on Pathogenic): Beitr. z. path. Anat. u. z. allg. Path., vi. 1889, p. 279. **Looss:** Ueb. Degenerations-Erscheinungen im Thierreich (Prize Essay, Leipsig), 1889. **Lubarsch** (On Bactericidal Properties of Blood): Centralbl. f. Chir., xvi. 1889, p. 852. **Massart** (Chimiotaxis and I.): Ann. de l'Inst. Pasteur, vi. 1892, p. 321. **Massart and Bordet** (Chimiotaxis): Ann. de l'Inst. Pasteur, v. 1891, p. 417. **Metchnikoff:** Fortschr. d. Med., ii. 1884, p. 558; Arch. f. path. Anat., xcvi. 1884, p. 177; *Ibid.*, cvii. 1887, p. 209; *Ibid.*, cix. 1887, p. 176; *Ibid.*, cxiii. 1888, p. 63; *Ibid.*, cxiv. 1888, p. 465; *also*, Ann. de l'Inst. Pasteur, iii. 1889, p. 25; *Ibid.*, iv. 1890, p. 620; *Ibid.*, v. 1891, pp. 465, 479; *Ibid.*, vi. 1892, pp. 1, 289; (Theory of Alexocytes) *Ibid.*, vii. 1893, p. 50; Brit. Med. Journ., 1891, i. p. 213; Journ. Path. and Bacteriology, i. 1892, p. 13; On the Comparative Pathology of Inflammation, 1893. **Mironoff** (Immunisation of Rabbit against Streptococcus, and Treatment of Streptococcus Septicæmia by Serum of Immune Animals): Arch. de méd. expér. et d'anat. path., v. 1893, p. 441. **Netschajeff** (Leucocytes and Infection): Arch. f. path. Anat., cxxv. 1891, p. 415. **Nowack** (Review of Recent Works): Schmidt's Jahrb., ccxxxix. 1893, pp. 75, 181. **Petermann** (Ogata's Bactericidal Subce. of Blood): Ann. de l'Inst. Pasteur, v. 1891, p. 506. **Prudden** (Germicidal Action of Blood): N. Y. Med. Rec., xxxvii. 1890, p. 85. **Ringer** (Increase of Leucocytes of Blood in Inflammation): Lancet, 1886, i. p. 107. **Roger:** Gaz. hebd. de méd., xxvii. 1890, p. 317; *Ibid.*, 337. **Roudenko** (Influence of Blood of Frog on that of Mouse): Ann. de l'Inst. Pasteur, v. 1891, p. 515. **Roux** (Preventative Inoculation): Public Health, Lond., ii. 1889-90, p. 65; *also*, Ann. de l'Inst. Pasteur, v. 1891, p. 517; *also*, Tr. VII. Internat. Cong. Hyg. and Demog., 1892, ii. p. 110. **Roux and Chamberland** (Against Vibrion Septique): Ann. de l'Inst. Pasteur, i. 1887, p. 561. **Ruffer:** Brit. Med. Journ., 1890, i. p. 1177; *also*, Quart. Journ. Mic. Sc., xxxii. 1891, p. 99; *also*, Ann. de l'Inst. Pasteur, v. 1891, p. 673. **Sanarelli:** Ann. de l'Inst. Pasteur, vii. 1893, p. 225. **Schütz** (Inherited I.): Arch. f. wissensch. u. prakt. Thierheilk., xix. 1893, p. 233. **Schwarz:** Wien. med. Wochnschr., xli. 1891, p. 2089 *et seq.* **Siebel** (Future of Foreign Bodies in Blood): Arch. f. path. Anat., civ. 1886, p. 514. **Turner:** Brit. Med. Journ., 1892, ii. p. 989. **Unna** (Inflammation and Chimiotaxis): Berl. klin. Wochnschr., xxx. 1893, p. 471. **Virchow** (the War between Cells and Bacteria): Arch. f. path. Anat., ci. 1885, p. 1. **Weyl** (Anthrax): Ztschr. f. Hygiene, xi. 1891-92, p. 381. **Wolfheim** (Phagocyte Doctrine): Beitr. z. path. Anat. u. z. allg. Path., iii. 1888, p. 403. **Wood and Ross** (Inflammation and Immunity): Rep. Lab. Roy. Coll. Phys., Edin., iii. 1891, p. 296. **Woodhead and Wood** (Action of Bacterial Products on Infective Disease): Lancet, 1890, i. p. 393. **Wright** (Wooldridge's Method of Producing Immunity): Tr. VII. Internat. Cong. Hyg. and Demog., 1892, ii. p. 164. **Ziegler:** Beitr. z. path. Anat. u. z. allg. Path., v. 1889, p. 416; *also* (Historical and Critical Review of Inflammation), Beitr. z. path. Anat. u. z. allg. Path., xii. 1892, p. 152.

CHAPTER XCV

SYSTEMATIC BACTERIOLOGY—(*Continued*)

The Organisms of Suppuration.

1133. These are chiefly staphylococci and streptococci. By **Staphylococcus** (Ogston) is meant a round organism which tends to become agglomerated into little bunch-of-grapes-like masses (σταφυλή, a cluster of grapes, and κόκκος, a kernel). By **Streptococcus** is understood a like round organism which ramifies in chains, the one member adhering to the other (στρεπτόν or στρεπτός, a chain). Sometimes these round organisms are arranged in couples or **Diplococci**.

The cocci, however, are not the only pyogenic microbes; there are several bacilli which are similarly endowed. They used to be looked upon as harmless saprophytes. Under certain circumstances, however, some of them may become generators of pus.

The following may be taken as the most important members of the cleft-fungi having pyogenic properties:—

Staphylococcus (*Streptococcus*) *Pyogenes Aureus.*

This is the organism which perhaps is commoner than any other in suppurating parts. It occurs in typical bunch-of-grapes-like masses (Fig. 577), sometimes in the form of chains. It is most abundant in the yellow pus of acute closed abscesses, and in fact in pus almost from whatever source derived; it is the organism which is most abundant in the suppurating marrow of acute osteo-myelitis. When combined with staphlyococcus p. albus it is said to induce a more severe inflammation than when alone (Watson-Cheyne, No. 642, p. 15). Garré (No. 11, iii. 1885, p. 165) found it in the blood in cases of osteo-myelitis. The frequency with which it is present in pus seems to vary with the locality. Thus, according to Levy (No. 104, xxix. 1892, p. 136), it is not so common in abscesses in Strassburg as the Staphylococcus pyogenes.

The optimum temperature is from 30° to 37° C., but it also grows, although more slowly, at temperatures which are lower. At high temperatures it shows within twenty-four hours as a faintly opaque line. It is at first of a pale yellow tint, but as the area of the culture increases it becomes more of an orange yellow. The colour shows best against a black background, but is never deep orange. When the surface-growth on agar has developed to its full extent, it looks very much as if a brush dipped in pale yellow oil paint (Fig. 505) had been drawn in a somewhat sinuous manner over the surface of the medium. After a time it ceases to extend. It emits a peculiar sour-milk-like odour.

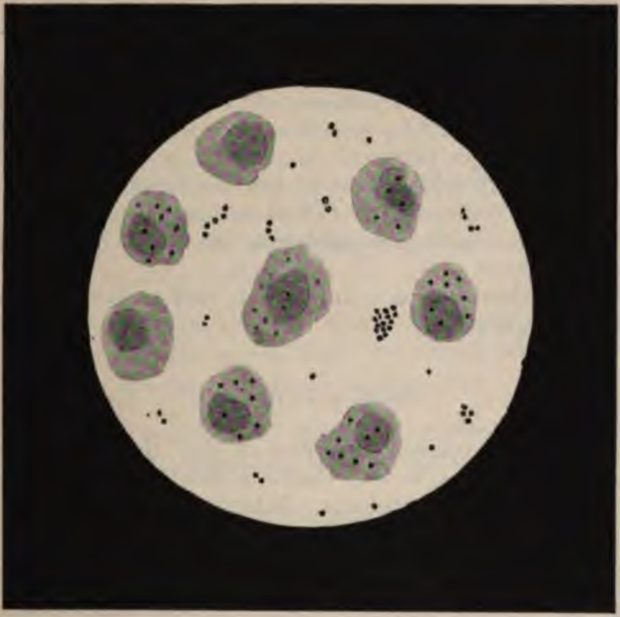


Fig. 577.—Pus from an Abscess showing Staphylococci and Streptococci, some of them contained in Pus Cells ($\frac{1}{12}$ homog. imm. Beck, Oc. No. 4 Hartk., tube out; stained with fuchsin).

On puncture in agar the growth constitutes an opaque yellow column, and in gelatine it scoops out a cupola of liquefaction within forty-eight hours. This extends rapidly downwards, so that soon the greater part of the medium becomes liquefied; the liquid has a pale yellow colour. It grows luxuriantly on bouillon, and on potato spreads out in a yellow thick layer. The colour is developed only on exposure to the air. It grows under oil, but the growth is colourless. The culture retains its virulency for long.

The coccus is very small, about 0·9 to 1·2 μ in diameter, and the members tend to hang together in bunch-of-grapes-like masses or like masses of fish spawn. It has a fatal action on rabbits and dogs when injected into a joint such as the knee or into the pleural cavity. The fatal result usually ensues in rabbits within twenty-four hours. If they survive, severe inflammation sets in. It does not cause putrefaction, nor is its growth accompanied by the evolution of gas.

It colours with different staining reagents, and is not decolorised by Gram's method.

Staphylococcus (Streptococcus) Pyogenes Albus.

Rosenbach (No. 582, 1886, p. 405) describes this as growing luxuriantly on agar in white masses. After a time the culture dries up and can be with difficulty inoculated on a fresh tube; but in flasks devoid of air it may be preserved in an active state for years. Gelatine becomes rapidly liquefied by it, and the liquid is always milky, never yellow. It does not grow so well on agar as the aureus. Microscopically it cannot be distinguished from the aureus. Its pathogenic action is also similar.

Next to Staphylococcus p. aureus it is said to be the commonest organism of suppuration.

Streptococcus Pyogenes.

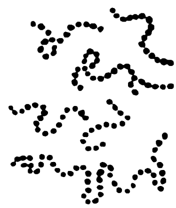


FIG. 578.—CULTURE OF STREPTOCOCCUS PYOGENES ($\frac{1}{12}$ homog. imm. Beck, Oc. No. 4 Hartk.; stained with fuchsin).

This is a very common organism of pus. It is found in acute abscesses and takes the form of chains or zoogloea. It is from 0·8 to 1 μ in diameter. When stained it is not decolorised by Gram's process. On gelatine it forms whitish round spots of the size of small grains of sand. It grows sparingly and very slowly on this medium, and does not liquefy it. On agar its growth is more active. The best temperature is from 35 to 37° C. It still has the same tendency to develop in points, each about the size of a pin's head. Sown in a line the bulk of the growth maintains this character, but here and there it shows a tendency to break off into the above-mentioned little specks or spots. As time goes on the edges of the line become thickened so as to constitute a terrace-like border on each side. It increases so slowly that even after a matter of weeks the streak may not be more than from two to three mm. wide. It may have a brownish colour. It will also grow on blood-serum.

Rosenbach found it in eleven out of twenty-six cases of unopened abscesses, and thrice along with staphylococcus p. aureus. Passet even

FIG. 503.—OIDIUM ALBICANS. Surface-culture on peptone-gelatine. It shows the peculiar characteristics of a mould colony, namely, a central dense part with numerous root-like offshoots emanating from the margin.

FIG. 504.—BACILLUS OF ANTHRAX. Puncture-culture on peptone-agar. A gray film overspreads the surface. The line of puncture is well marked, while from it multitudes of arms or processes radiate into the surrounding medium.

FIG. 505.—STAPHYLOCOCCUS PYOGENES AUREUS. Surface-culture on peptone-agar. The growth closely resembles a flake of yellow oil-paint drawn in a sinuous manner over the surface.

FIG. 506.—BACILLUS OF GLANDERS. Surface-culture on potato. Grows as a slimy deposit which has a brownish-yellow colour.

FIG. 507.—BACILLUS OF GLANDERS. Surface-culture on peptone-gelatine. The growth has a honey-like consistence and colour, and is perfectly homogeneous. It spreads out in spatula form at the lowest extremity and is pointed above.

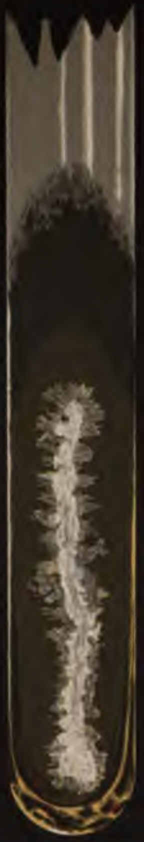


Fig. 503.

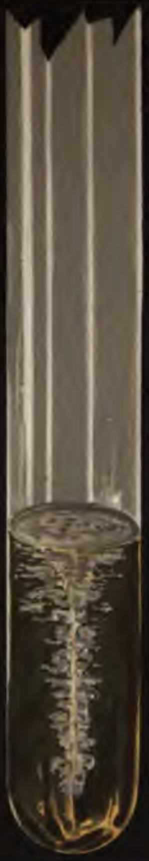


Fig. 504.

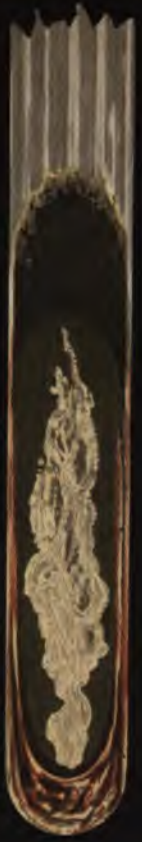


Fig. 505.

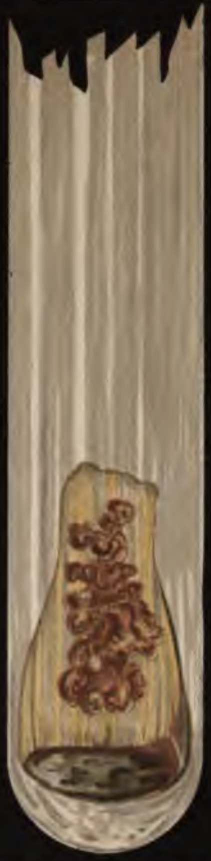


Fig. 506.

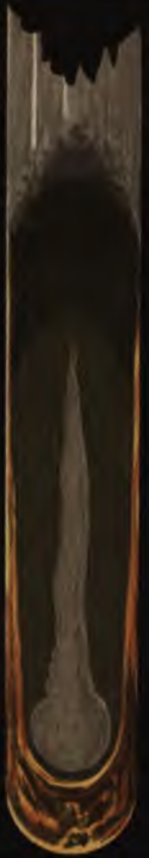


Fig. 507.

R & R Clark. Edinburgh

alleges that it is commoner in abscesses than the Staphylococcus p. aureus. It has been found also in the vegetations of malignant endocarditis and in osteo-myelitis (Krause and Becker). It is said by Passet to withstand a boiling temperature. It has the property of inducing abscesses when injected subcutaneously or into various organs.

This organism, as before remarked (p. 876), appears to be identical with the streptococcus of erysipelas.

On further growth a second terrace-like elevation rises up outside the first, but somewhat flatter. The growth is throughout slow, and it does not liquefy the gelatine basis. It, however, quickly breaks up beef and egg albumin in airless chambers without production of foul smell or of any marked amount of gas.

Rabbits are not much affected by it beyond its inducing a localised inflammatory nodule or abscess. Mice are more susceptible; it often proves fatal when inoculated subcutaneously in them.

All these may be found in unopened abscesses.

Micrococcus Pyogenes Tenuis.

The term was applied by Rosenbach to this somewhat rare microbe on account of the delicacy of its colonies. The cocci lie together in small numbers; they are not arranged in groups. Surface cultivations on agar produce a thin film almost as transparent as glass or thin varnish, with a dark central streak corresponding to the needle track. The individual micrococci are somewhat larger than the staphylococcus aureus or albus, and often show two dark stained poles with less stained material between them. The organism appears to have only local pus-forming properties.

Staphylococcus Pyogenes Citreus, Staphylococcus Cereus Albus and Flavus.

These appear to be of little importance. In fact, the last two do not seem themselves to cause suppuration, but merely to accompany it.

Micrococcus Tetragenus.

This has been found in pus several times. It is pathogenic for mice and guinea-pigs, but it is questionable whether it has pyogenic properties. (For further particulars see Sect. 1150.)

Bacillus Pyogenes Fœtidus.

Discovered by Passet (No. 11, iii. 1885, p. 68) in an abscess in the neighbourhood of the anus (No. 650, p. 51), it is generally associated with other organisms of suppuration. Krynski (ref. in No. 651, i. 1890, p. 744; orig. in Polish) comes to the conclusion that it can excite suppuration in healthy tissues.

Bacillus Intracellularis Meningitidis.

Neumann and Schäffer (No. 13, cix. 1887, p. 477) have isolated a bacillus from the exudate of purulent meningitis which apparently belongs to the pyogenic organisms. Its cultures are very much like those of typhoid. Weichselbaum (No. 11, v. 1887, p. 573) found it in six cases of cerebro-spinal meningitis. It often takes the form of diplococci, and in sections of the spinal cord is found within the nerve cells. It colours with Loeffler's methylene blue, and decolorises by Gram's method. Dogs inoculated on the dura mater with the organism die from pachymeningitis.

Gonococcus.

The properties of this organism as an exciter of catarrhal suppuration are undoubted. The organism, however, has already been described (p. 368).

Among the pyogenic *bacilli* the following may also be mentioned :—

Bacillus of Typhoid Fever.

In periosteitis, pleurisy, etc., following typhoid the characteristic organism has been found, and the general impression is that it is capable of exciting the suppuration accompanying those conditions (see *Typhoid*, Sect. 860).

Bacillus Pyocyaneus.

This is the organism of blue pus. It is questionable whether it is possessed of pyogenic properties. The general opinion is that it is not. The fact that it is so often associated with suppurations is sufficient excuse for describing it under the present heading.

It is even said by some authors that it is not pathogenic. With this Charrin (No. 641, p. 25) cannot agree. By passing the organism several times through the body of the rabbit it acquires characters which are decidedly pathogenic, and which frequently end in death. According to the quality and quantity of the virus injected the disease induced by it may assume an acute or a chronic type. In the very acute types the symptoms are those of loss of appetite, somnolence, and often, at the close, convulsions, together with fever, diarrhœa, and albuminuria. It never seems, however, to induce blue suppuration. In less severe forms, among other phenomena, there is motor paralysis. It appears to be pathogenic for a number of animals whose temperature is widely different, such as the pigeon, rabbit, guinea-pig, and frog.

It is composed of short rods from 1 μ to 1·5 μ long by 0·6 μ broad. So short is it that it is often mistaken for a micrococcus. It is grouped in chains, in twos and threes, or in little heaps.

In **bouillon** it is very motile. On **agar** it forms a film on the surface, the blue-green fluorescent colouring matter underneath. On **potato** the growth has a brown colour and a mucous consistence. If the deepest part of the culture is exposed to air it becomes green. The green colour is encouraged by alkalinity of the basis ; an acid reaction causes it to assume more of a red tint, which in course of time becomes brownish red. On **milk** it first precipitates the casein, then dissolves it, and in doing so disengages ammonia. When this happens, the milk becomes blue-green in colour. Puncture cultures on gelatine begin to liquefy the medium in forty-eight hours. In the course of eight days a cupola of liquefaction has developed at the upper end of the track.

Charrin states (No. 641, p. 13) that it develops arthrospores. The contents of the bacilli become condensed in one or two globules around which the enveloping membrane thickens. These condensed parts become, so to speak, encysted cells or arthrospores. Their resistance to heat and to colouring matters is greater than that of the bacilli themselves.

It grows without air, but under such circumstances fails to secrete the characteristic colouring matter (see Sect. 1114).

Lastly, it should be mentioned that it does not grow on pus alone; it has been found in the sweat of an individual suffering from tetanus, and imparting to it the blue colour.

Bacillus Septicus Vesicæ.

This organism was found by Clado in persons suffering from pyo-nephritis and cystitis. It is a motile rod which is not decolorised by Gram's process. It does not liquefy gelatine, and in a plate culture develops punctiform colonies which remain very small. On agar there shows a delicate film, and upon this numbers of milk-white colonies develop. Both gelatine and agar rapidly become alkaline. It grows readily in bouillon. On potato it forms a dry light-brown layer.

Urobacillus Liquefaciens Septicus.

This also is found in the pus of pyo-nephritis and cystitis. The rods are short and motile, with rounded ends. They liquefy gelatine, and are decolorised by Gram's method. One distinctive feature of the growth is the occurrence of a nodule in the centre of the liquefied gelatine, the size of a hemp seed, and with fringed or frayed margins. On agar the organism spreads out in a grayish-white, smooth pellicle. Ammonia is evolved from the cultures with a smell of decomposed urine.

INOCULATION OF PYOGENIC ORGANISMS ON MAN.

1134. Not only has the pyogenetic power of these organisms been proven experimentally in animals, but similar proof of it has been forthcoming in Man. By personal inoculation Bockhardt has shown that an admixture of staphylococcus p. aureus and albus introduced into the skin of the finger is capable of forming an abscess within forty-eight hours. In the pus of the abscess the aureus was again found.

A common form of infection from the cadaver is that of an eruption of a number of small furuneuli on the infected parts. They appear in from twenty-four to thirty-six hours after exposure to the poison. Garré has induced a similar eruption on the arm by rubbing in a pure culture of staphylococcus p. aureus. The pustules usually fade after a few days, while in some cases they assume almost carbuncle-like characters. The latter was the history of Garré's self-imposed experiment. The inflammation around the pustules became so extreme that they developed into bodies having quite the characters of huge carbuncles. Where there is no actual abrasion or wound of the surface the poison finds entrance apparently by the sweat glands, sebaceous glands, and hair follicles.

THE RELATIONSHIP OF THE MICRO-ORGANISMS OF PUS TO SUPPURATION.

1135. This subject has already been referred to (vol. i. p. 263). In addition it may be remarked that Hueter's original dogma of "no suppuration without micro-organisms" has met with pretty general acceptance of late years, although requiring to be limited in some respects. Ogston's observations (see Bibliog.) go to support the view that whereas the pus of acute and pyæmic abscesses always contains microphytes, that of chronic cold abscesses usually does not. The pus of the former is eminently harmful when introduced in sufficient quantity into the circulation of animals, and this harmfulness is lost when the organisms contained in the pus are destroyed by heat or carbolic acid.

Like most people, however, Ogston does not absolutely deny that suppuration may occur in the absence of such micro-organisms, and this is the tendency which opinion of late years has taken. Steinhaus, for instance (No. 643, p. 174), after much experimental investigation, has come to the conclusion that purely chemical substances in properly constituted animals, and in proper doses, may induce a suppuration even when they are quite sterile. A great deal seems to depend upon the animal employed. Substances secreted by bacteria and freed from the bacteria themselves are highly pyogenic.

It may be mentioned in this connection that chronic abscesses are often of tubercular origin, and spring from tubercular bone. The discharge from such, although it may not contain ordinary pyogenic organisms, does contain very frequently the bacillus of tubercle.

SOURCES FROM WHICH PYOGENIC ORGANISMS ARE DERIVED.

1136. According to Watson-Cheyne (No. 641, p. 89) pyogenic organisms are very rarely present in putrefying fluids. They are sometimes present in the superficial layers of the soil. One of the commonest seats outside the body is the skin, especially where it is moist, as, for example, in the axillæ, between the nates, between the toes, etc. They are also frequently present on the hair and in the dirt beneath the nails. In the pharynx and in nasal mucus they have been found even when these are healthy.

They enter wounds chiefly by extending inwards under the dressings from the adjacent contaminated skin. The dead epidermis at the sides of such wounds is a soil upon which they readily flourish. They apparently but seldom fall into the wound from the air. The hands of the surgeon or of his assistants are no doubt a ready means of conveying them to fresh wounds. And not only so, but articles of constant use in a ward or other sick chamber are liable to be smeared with them through the hands of those engaged in dressing. From these articles they may easily find access to wounds as yet uncontaminated.

Formation of an Abscess.

1137. When suppurative cocci are introduced into the tissues of a living animal they soon begin to fructify in the part. Around them the tissues assume a somewhat homogeneous appearance, and are evidently dead or dying. This is probably the result of the caustic action of their chemical products. The state of the part resembles that of the cornea when touched with a point of nitrate of silver. Outside this dead area there forms, after a day or two, a dense ring or barrier of small round cells, which, it is alleged, acts as a defence against the cocci spreading diffusely. The small round cells behave like the cells of ordinary granulation tissue. The dead area next becomes penetrated by the cocci on the one hand, and by the small round cells on the other. Its tissues dissolve, or at least soften, probably by the action of the enzymes secreted by the cocci, and soon a central core or slough of the part results. The small round cells form the pus, and in an ordinary furunculus, for example, these and the central dead core are voided when the abscess is opened.

Strangles.—By this is meant a disease of the horse characterised by the occurrence of abscesses in the lymphatic glands of the submaxillary, sub-parotidean, and retropharyngeal regions. Not only a set of glands, but the surrounding tissues for some distance may be involved in the suppuration. In some cases the abscesses may be the size of the fist, in others the glands become enlarged, but suppurate only in parts. Schütz (No. 652, xiv. Heft 3; *Eng. transl.*, No. 445, i. 1888, p. 191) has isolated what appears to be a specific streptococcus from the pus.

PYÆMIA AND PYOGENIC ORGANISMS.

1138. This subject has already been discussed (vol. i. p. 677). It may just further be remarked that it is doubtful if acute pyæmic abscesses are the result of the organisms of suppuration circulating free in the blood. We know that they may be present in great numbers in the blood without giving rise to abscesses. They are evidently much more likely to excite an acute abscess when attached to fragments of clot or other dead tissue. One notorious cause of pyæmia is the occurrence of suppuration within a clot in a vein, and the transportation of its fragments to a distance by the blood-stream. Possibly the explanation is that the embolus, by containing a large quantity of a particular organism, offers features more difficult to be combated by the tissues than when the warfare is carried on against the same noxious agent singly and individually.

It is otherwise, however, when a tissue or organ is weakened from any cause. Then the organisms circulating in the blood can easily overcome its feeble powers of resistance, and an abscess or a series of abscesses follows.

When pus containing the organisms of suppuration is injected into the circulation, or even into the peritoneum (Ogston) in small quantity, it may not lead to any harmful result. Not being in overwhelming quantity, the organisms can be overcome by the blood phagocytes, or may in part be eliminated by the kidney. Schweizer (No. 13, cx. 1887, p. 255) found that when a green coloured organism, with which he experimented, was injected into the renal artery, it was thrown out readily in the urine. How they manage to pass the renal capillaries has not been thoroughly explained.

The blood-serum of patients suffering from suppuration, according to Nissen (No. 49, 1892, i. Ab. 2, p. 275), is poisonous to mice when injected into the jugular vein, while normal serum has no effect.

SEPTICÆMIA.

1139. The literal meaning of the word is that of "putrefying blood" (σηπτικός, putrefying, and αἷμα, blood), or a condition in which putrefying matter has been introduced into the blood. As our knowledge of the poisons fabricated by micro-organisms became more and more advanced the idea entertained by surgeons was that pyæmia represented a state of body in which the organisms of putrefaction were themselves taken up from an open wound or other source of contamination. It was supposed that they circulated in the blood, and gave rise to abscesses wherever they alighted. Septicæmia, on the other hand, was held to be a morbid state of body induced by the absorption not of the organisms, but of the poisons formed by them. And the general character of the disease favoured this idea. The affected individual was suffering from an open wound or, it might be, was a woman lately delivered of a child. The wound had putrefied or a similar state of matters was present in the lochial discharges. Feverish symptoms, with vomiting and diarrhœa, set in and the sufferer died. After death no particular lesion was to be seen, with the exception perhaps of punctiform hæmorrhages in the serous membranes and elsewhere. There was an absence of pyæmic abscesses, an absence possibly even of slight pleurisy or peritonitis. The cause of death certainly was not apparent, and it was supposed that it resided in the absorption of the poisons generated in the wound.

Septicæmia of Mice.—In studying this subject experimentally, it was found by Koch (No. 653) that, if a comparatively large quantity of a putrid fluid is injected under the skin of a mouse, the animal dies within a few hours, apparently from the quantity of toxic products injected.

If, however, only a few drops of such putrid fluid are employed, the quantity of toxine is not sufficient to kill the animal at once. In a large proportion of cases, however, the animal contracts a bacillary disease, showing its first symptoms generally after twenty-four hours, and dies within from forty to sixty hours after inoculation. The same disease can be propagated, over and over again, in fresh hosts from the blood of the already affected. There is thus established a disease in mice characterised by the presence within the blood of a short rod (·8 to 1 μ long, and, approximately, ·1 to ·2 μ broad), and to this disease Koch applied the name *Septicæmia of mice.* The organism is generally known as *Bacillus murisepticus.* It is immobile and retains its stain by Gram's process. It does not liquefy gelatine.

Field-mice and guinea-pigs are immune.

Septicæmia of Rabbits.—Similarly, when (p. 53) he injected putrid fluids beneath the skin of rabbits, they gave rise to a local putrid suppuration of the part, and the animal died in about three days and a half, with its blood teeming in this instance with what he described at that time as an oval micrococcus. This disease could also be transmitted from one animal to another. The so-called coccus was named by Koch the *Micrococcus of Septicæmia of Rabbits.*

Since then it has been found that this organism is a minute rod, and that it is identical with what have been described variously as the bacillus of fowl cholera, an organism obtained by Gaffky (No. 44, i.) from the water of the river Panke, and the organism of what is known as Davaine's septicæmia (No. 153, 1872, 1873). It also appears to be identical with the organism of the diseases of animals known in Germany as *Wild-* and *Rinderseuche.* Accordingly, at the present time, it is customary to look upon the diseases in which it plays the essential part as of the same nature, and to include them under the generic term of **Septicæmia hæmorrhagica,** the organism being known as **Bacillus septicæmiæ hæmorrhagicæ.**

This organism is widely disseminated in nature and enters into most putrefactive liquids. On accurate measurement it proves to be from 1·4 μ long by 0·6 to 0·7 μ broad, with round ends, and with this peculiarity that, when stained, the colouring matter fixes itself upon each end, and on superficial examination gives rise to the appearance of two cocci held together. Pasteur indeed described it in fowl cholera as a diplococcus.

It grows readily on different media, and can be inoculated easily upon various animals such as the chicken, pigeon, pheasant, rabbit, mouse, pig, and deer.

Whether it ever grows upon the blood of Man is unsettled. Indeed we are peculiarly ignorant of what the organisms are which grow on the blood of Man as a result of putrefaction. We know what those are which accompany suppuration, but suppuration is not necessarily synonymous with putrefaction. Those organisms which are the chief cause of suppuration do not occasion putrefaction. Whether there are diseases in Man which correspond with those of the mouse and rabbit just referred to is as yet unascertained.

In two cases of puerperal fever Doléris found that the blood was free from organisms until just before death. He found further that, on their appearance, they were of different kinds, and that a constant and abundant supply of them in the wound or other source of infection renders the chance of their becoming acclimatised upon the blood greater than where the supply is small.

The lesson therefore to be derived from these experiments is that putrid fluids can and do confer specific microbal diseases upon animals, the particular animal picking up from the many organisms growing in the putrefying part the one which grows most readily upon its blood. So far as our knowledge goes, therefore, we are entitled to define septicæmia as *a class of diseases induced primarily by putrefactive liquids in which different organisms are appropriated by different hosts and live upon the blood of the host.* They do not usually give rise to suppuration, but prove fatal probably through the toxic products secreted by them.

SAPRÆMIA (*σαπρός, rotten or dead*).

1140. It is possible, however, that before the organisms growing in the putrefactive focus have found their way into the blood, the system may have become poisoned by the toxines secreted by them.

We know that certain of the organisms which are commonest in putrefactive liquids, such as proteus, secrete violent poisons (Hauser, No. 649), and there seems good reason for believing that these may be absorbed and give rise to a fatal disease without the organisms which are the source of the poison being spread broadcast throughout the system. We have analogous instances of this in the case of tetanus and diphtheria. One of these poisons, namely **sepsin,** develops in putrefying blood. When injected into the jugular vein of the dog it induces vomiting and hæmorrhagic diarrhœa.

On the understanding that such is possible in the case of putrefactive disease, if we may so express it, the term *Sapræmia* (Duncan) is peculiarly appropriate.

Literature on Causes of Suppuration, Pyæmia, Septicæmia, and Sapræmia.—**Andrewes:** Rep. Med. Off. Loc. Gov. Bd., xx. 1891, p. 273; *Ibid.*, xxi. 1893, p. 209. **Blumberg:** Arch. f. path. Anat., c. 1885, p. 377. **Bumm:** Sitzungsb. d. phys.-med. Gesellsch. zu Würzburg, 1888, p. 95. **Burginsky** (Staphylococcus Pyogenes Aureus): Arb. a. d. Geb. d. path. Anat. . . . Inst. zu Tübing., i. 1891, p. 63. **Cadéac** (Pyocyanic Microbe): Compt. rend. Soc. de biol., ii. 1890, p. 41. **Charrin:** La maladie pyocyanique, 1889; *also*, Une Septicémie expérimentale, 1885. **Cheyne:** Suppuration and Septic Disease, 1889. **de Christmas:** Ann. Instit. Pasteur, ii. 1888, p. 469. **Crookshank** (Question of Identity of Strept. Pyogenes and Strept. Erysipelatosus): Tr. VII. Internat. Cong. Hyg. and Demog., 1892, ii. pp. 67, 68. **Dallinger:** J. Roy. Micr. Soc., Lond., v. 1885, p. 177. **Dreyer:** Centralbl. f. d. med. Wissensch., xi. 1873, p. 929. **Feltz** (Experimental): Compt. rend. Acad. d. Sc., lxxx. 1875, p. 1338; *Ibid.*, lxxxiv. 1877, p. 1324. **Ferrari:** Sul bacillo piocianico, 1889. **v. Fodor** (Injection of Bacteria into the Veins): Deut.

med. Wochnschr., xii. 1886, p. 617. **Forgue**: Des septicémies gangreneuses, 1886. **Fraenkel** (Organisms of): Zeitschr. f. klin. Med., x. 1885, p. 402; *also*, Wien. med. Wochnschr., xxv. 1885, pp. 108, 141, 173. **Garré**: Fortschr. d. Med., iii. 1885, p. 165. **Gessard** (Pyocyanic Microbe): Ann. de l'Inst. Pasteur, iv. 1890, p. 88. **Hauser**: Ueb. Faulnissbacterien. u. d. Beziehungen zur Septicaemie, 1885. **Hiller**: Centralbl. f. d. med. Wissensch., xii. 1874, pp. 323, 337, 353, 369. **Jankowski**: Beitr. z. path. Anat. u. z. allg. Path., viii. 1890, p. 221; *also*, Beitr. z. path. Anat. u. allg. Path. (Ziegler), vi. 1889, p. 225. **Jeannel et Laulanié**: Gaz. hebd. de med., xiv. 1885, p. 1194. **Kronacher**: Die Aetiologie u. d. Wesen d. akuten eitrigen Entzündung, 1890. **Leber**: Die Enstehung d. Entzündung, 1891. **Levy**: Arch. f. exper. Path. u. Pharmakol., xxix. 1891, p. 135. **Lister** (Micro-Organisms and Inflammation): Lancet, 1881, ii. p. 695. **Lucet** (in Bovine Species): Ann. de l'Inst. Pasteur, vii. 1893, p. 325. **Marthen**: Ueb. blauen Eiter, etc., 1890, Thesis. **Matthews-Duncan** (Sapræmia): Lancet, 1880, ii. p. 684. **Mironoff** (I. against Streptococcus): Compt. rend. Soc. de biol., v. 1893, p. 400. **Nathan**: Arch. f. klin. Chir., xxxvii. 1888, p. 875. **Neumann**: Ztschr. f. klin. Med., xix. 1891, Suppl.-Hft., p. 122. **Ogston**: Brit. Med. Journ., 1881, i. p. 369; *also*, Journ. Anat. and Physiol., xvi. 1882, p. 526; *Ibid.*, xvii. 1883, p. 24. **Passet**: Fortschritte d. Med., iii. 1885, p. 33 *et seq.* **Petri** (Malignant Œdema): Centralbl. f. d. med. Wissensch., xxii. 1884, pp. 833, 849. **Ribbert**: Deut. med. Wochnschr., xv. 1889, p. 101. **Richet**: Arch. de méd. expér. et d'anat. path., i. 1889, p. 673. **Roger**: Compt. rend. Soc. de biol., iv. 1892, p. 824. **Rosenbach**: *Eng. Transl.* N. Syd. Soc., 1886, p. 397. **Steinhaus**: Die Aetiologie d. acut. Eiterungen, 1889. **Wassilieff** (Micrococci in Vessels): Centralbl. f. d. med. Wissensch., xix. 1881, p. 929. **Winkler and Schrötter** (New Green Organism): Mitth. a. d. embryol. Inst. d. k. k. Univ. Wien, 1890, p. 60. **Wyssokowitsch** (Injection of Micro-organisms into Blood): Ztschr. f. Hyg., 1886, i. p. 3. **Zuckermann** (Cause of Suppuration): Centralbl. f. Bacteriol. u. Parasitenk., 1887, i. p. 497.

ACTINOMYCOSIS.

1141. **Definition.**—*A disease common to many animals and to Man, caused by the vegetable parasite known as actinomyces or ray-fungus.*

Historical.—The name Actinomyces or Strahlenpilz was given to the parasite by Harz (No. 50, xv. 1877, p. 484).

Notwithstanding that the disease is one to which cattle fall a prey much oftener than Man, yet curiously it was in Man that the parasite was discovered. On Israel showing v. Langenbeck the surgeon some of the pus preparations taken from the human subject, the latter was reminded of a case which came under his notice in the year 1845 while at Kiel, in which the characteristic cylindrical fungus, radially arranged, was found. v. Langenbeck's case was one of vertebral abscess with fistulous openings. Among the discharge little tubercle-like bodies were discovered, which on microscopic examination proved to be the fungoid masses (see account of this case, No. 13, lxxiv. 1878, p. 50).

It remained, however, for Bollinger (No. 50, xv. 1877, p. 481) and Israel (No. 13, lxxiv. 1878, p. 15) practically to rediscover the disease, the former in the jaws of cattle, the latter, a little more than a year later, in the human subject. Israel gave what is almost a complete set of drawings of the morphological phases of the life history of the parasite. Ponfick shortly afterwards (No. 43, xvii. 1880, p. 660) confirmed Israel's observations.

In animals the tumours long went by various indefinite names, such as *osteo-sarcoma*, *spina ventosa*, *lymphadenoma*, etc.

The Disease in Animals.—Oxen are perhaps more subject to the disease than other animals, and in them the tongue and jaws are the parts most often affected. The tongue becomes swollen and so hard that the term **wooden tongue** is applied popularly to it. Small tumour-like deposits are seen within it, the seat of the fungus. The jaws also become infiltrated with the tumour masses; they suppurate and discharge through intractable sinuses. The bone becomes opened into, and new bone is thrown out in irregular masses.

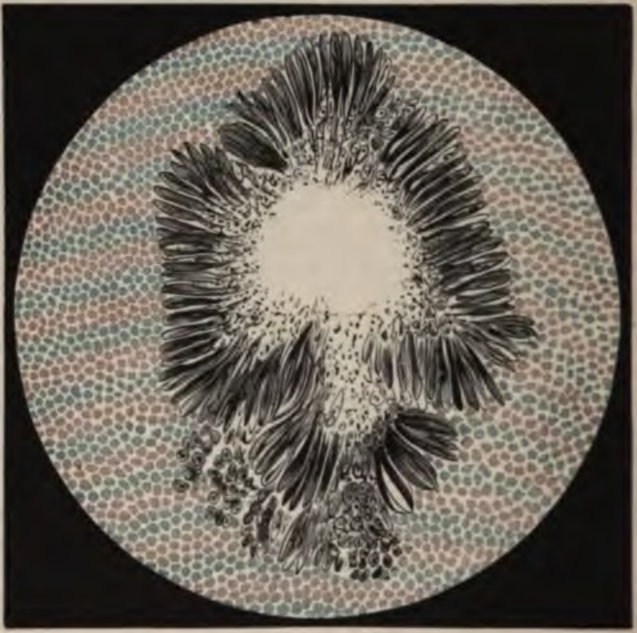


FIG. 579.—ACTINOMYCES FROM HUMAN LIVER.

The lung is not so often implicated in cattle as other parts, but the pharynx, larynx, œsophagus, and intestine frequently contain the tumour-like deposits. The disease is slow in its course, and tends to spread from one organ to another. In some cases the subcutaneous tissue of the head and neck is the seat of it.

It was first described in horses by Rivolta and Johne. The stump of the spermatic cord after castration becomes infected with a parasite (discomyces), and assumes a scirrhous-tumour-like appearance (scirrhous cord), not unlike that induced by actinomyces. Dogs and pigs are both subject to actinomycosis; in the pig the disease assumes the form of pharyngeal abscesses, and also affects the mammary gland.

The Disease in Man.—In Man the actinomyces give rise to tumour formations and abscesses. There is hardly an organ or tissue in the body which is exempt from them. Thus they are often found in the lung and liver; in bone they occasionally take up their residence; and in a case described by Delépine (No. 192, xl. 1888-89, p. 420) they gave rise to multiple tumours and abscesses in the substance of the cerebral hemispheres.

The tumour in the lung might be mistaken, on careless examination, for a sarcoma. It is a peribronchitic growth, and on section presents a peculiar foliated appearance, which once seen is not readily forgotten. It varies in size from a millet seed to that of a walnut. In the abscesses Delépine was able to detect minute clumps scattered through the contents. On compressing them, and with the use of a high power, they were seen to be made up of coarse branching filaments.

According to Israel (No. 582, 1886, p. 463) there are three paths of entrance in Man—(1) the mouth and pharynx; (2) the respiratory passages; and (3) the digestive tract. Rarely the parasite may be localised in the lower jaw, neck, cheeks, bronchial mucosa, parenchyma of the lung, the chest wall, intestinal mucosa, peritoneum, or in a vertebral abscess. In bronchitis actinomycotica the sputum contains the parasite.

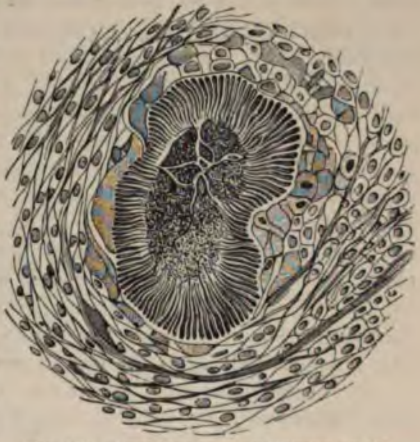


FIG. 580.—ACTINOMYCES FROM TONGUE OF OX.

As time goes on the centre of the mass becomes necrobiotic, an event which is accompanied by increase of the actinomyces groups. More or less pus shows itself, and not unfrequently there are slight hæmorrhages. Cavities are thus formed filled with soft material composed of pus cells, fat, blood-corpuscles, blood-crystals, and actinomyces groups. Around these, réactive fibrous tissue is thrown out. The walls of the cavities are shreddy, and the actinomyces groups are found clinging to the débris. In the lung, the future course of the disease is very much like that of ordinary phthisis. The prevertebral tissues are apt to become infected from the adjacent pleura. The disease may pass through the base of the lung and diaphragm into the abdomen or into the anterior mediastinum.

Morphology.—The forms which the parasite assumes are the following:—(1) **Coccus-like bodies** from $0{\cdot}5\ \mu$ in diameter. They are very numerous in the large colonies, but sometimes occur independently of these. (2) **Threads** $0{\cdot}6\ \mu$ in breadth or broader.

They are seen better in unstained than in stained preparations, and look broader when unstained, owing to the sheath being visible. When stained and clarified it is the contents of the thread alone which colour. They are sometimes segmented or even spirillar in form (M'Fadyean). In the tissues they occur without the clubs, or it may be that the clubs are found in one area, the threads in another. In most cases, however, it is the clubs, not the threads, which prevail. In Man, however, a tangled mass of threads and cocci is commonest. Seldom does it happen that the two are combined in the same focus. (3) **Club-forms.** Although these, as just said, are the commonest and most characteristic stage of actinomyces growth, yet by Boström (No. 654, 1885, p. 94) and others they have been considered as degenerate structures, involuted forms arising from arrest of growth. They are long clavate bodies, sometimes branched, and arranged in a radiate manner around a centre composed generally of granular matter. By their radiate arrangement they constitute rosette-like colonies of round or somewhat ovate shape (Figs. 579, 580). They are peculiarly homogeneous, and are made up of a membrane outside with clear, highly-refractile contents. The pointed end always looks towards the centre of the rosette. They are occasionally so loosely attached that they fall out in preparing the section. When they are combined with threads the threads lie among the granular débris. The end of a thread is held by Boström to run into the club and to be surrounded by its gelatinous contents. Indeed, the whole club is often regarded simply as a mucoid swelling of the end of the thread.

By others, however, the clubs have been looked upon as true reproductive organs, and, as supporting this view, spore-like bodies have occasionally been detected within them. These, however, after a time disappear.

Around the rosette of clubs there is generally a dense layer of small round cells forming what is usually held to be a protective barrier against the organism spreading. The central granular part of the colony sometimes becomes calcareous; the calcic material dissolves in mineral acids without effervescence (Delépine).

Classification and Life History.—This as yet remains somewhat unsettled. The clubs have been described as *spore-bearing basidia* or *conidia*. It has also been alleged that they resemble ascomycetes. Delépine (No. 192, xl. 1888-89, p. 429) remarks that there is a remarkable resemblance between them and the sphacelium of a claviceps (one of the pyrenomycetes). It is hard to say whether the clubs are asci or not, although, as before remarked, some of them contain spore-like structures.

Boström concluded that the fungus belongs to the Cladothrix group of Schizomycetes (p. 959), and that it is possibly identical with Streptothrix Försteri of Cohn. Certainly there is a close resemblance in the culture colonies of certain varieties of streptothrix and those of the parasite in question. In Fig. 495 is given a representation of a growth on agar of actinomyces, and in Fig. 497 one of streptothrix of Eppinger. In both there are the same spherical masses, easily detached, and when detached, retaining their circumscribed character to such an extent that they float about in the condensation liquid at the bottom of the tube.

Israel's view of the life history of the organism, as expressed in his original work on the subject (No. 13, lxxiv. 1878, p. 39), is as follows:—The feebly refractile micrococcus-like granules (Fig. 581, C) grow into threads (A) which are unsegmented, wavy, or, here and there, corkscrew-like, and by no means seldom dichotomously branched. The threads may throw off shining spore-granules at their ends or laterally. One free end of the thread swells into a highly refractile pear-shaped body or conidium (B); and this again (D) may divide into a number of segments by transverse fission. Pear-shaped bodies also are set free, and by budding, constriction, division, and falling to pieces, pass through a series of metamorphoses whose final result is the formation of shining irregularly-developed flakes and granules. Out of these apparently are produced the finest micrococcus-like bodies. These again elongate into filaments. He thus adopts two methods of genesis of these finest granules (cocci or spores), namely, from the filaments and from the pear-shaped conidia.

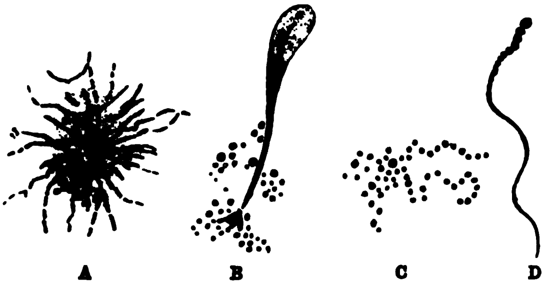


FIG. 581.—DRAWING ILLUSTRATING THE LIFE HISTORY OF ACTINOMYCES ACCORDING TO ISRAEL (after M'Fadyean; Reichert, $\frac{1}{12}$ oil immersion).

(A) Small colony showing central core of cocci (partly out of focus) and radiating filaments, some of the latter branched; (B) irregular group of cocci from which proceeds a filament ending in a club; (C) short chains of cocci; (D) cocci developed by close segmentation of a filament (Gentian-violet and Gram's Method).

Artificial Culture.—In order to succeed in cultivating the fungus artificially from an original colony in the tissues, it seems to be necessary that the colony be in the thread stage of development, not in that of clubs. Hence growths taken from Man are perhaps more successful than those from the lower animals.

On the surface of gélose it assumes the form, in from the third to the fifth day, of amber-bead-like isolated colonies (Fig. 495). They are peculiarly elevated and loosely attached, so that if there be any condensation liquid at the lowest part of the tube they are easily shaken off and fall into this. Here they remain in their bead form, and even although the tube is roughly shaken do not tend to break up. They are colourless at first, but become yellowish later on; they are also possessed of a peculiar amber-like transparency. The colonies while still adhering to the surface of gélose incline to run in lines or to become aggregated in groups, but do not coalesce. When looked at minutely or with a pocket lens, the margin of each colony is seen to be so elevated that in reality it forms a little ring with a dark spot in the centre.

Examined microscopically, the colonies are found to be made up of rods and straight or wavy threads, undoubtedly screw-like threads, and lastly, coccus-like bodies. It is rarely if ever that true clubs are met with. It has been asserted that in old growths they sometimes do appear. Wolff and Israel (No. 13, cxxvi. 1891, p. 38) state that when grown on raw or boiled eggs the filaments develop with particular richness, and that swellings of small size are to be seen on their ends. Boström described the same swellings, and looked upon them as rudimentary clubs. In rare instances the colony grows to a larger size and takes the shape of a rosette (Israel and Wolff).

Inoculation.—The credit of proving the inoculability of actinomyces undoubtedly rests with Wolff and Israel (No. 13, cxxvi. 1891, p. 11). They isolated it from the abscesses in Man and grew it upon various media. When a small quantity of a pure growth on agar or upon egg is introduced into the abdomen of animals it reproduces the disease with great certainty. They employed in one research twenty-three animals. Twenty-two of these were inoculated as above with actinomyces; one was inoculated with the sterile agar medium as a control experiment. Of the twenty-two animals selected, eighteen were rabbits, three guinea-pigs, and one a sheep. Of these only the sheep failed to contract the disease. In the others the peritoneum was found to be the seat of an eruption of small tumours; in one instance, the tumours were also found in the abdominal muscles; in another within the spleen.

The peritoneal tumours varied in size from a millet seed to a plum. In the surroundings of the larger tumours there were numerous smaller nodules. The disease, even when so extensive as to cover the entire peritoneum, did not always prove fatal, and even so late as from seven to nine months after infection.

The smallest tumours were surrounded by a connective tissue capsule, and had a sebaceous-like interior. In the case of the larger tumours the capsule was denser and sent in numerous fibrous septa. The contents separated into little seed-like masses, which, on being examined microscopically were found to be composed of the usual actinomyces forms including the clubs. But just as in human actinomycosis, there were many instances in which the threads were present without the clubs, or the clubs showed only at one part of the circumference.

Means of Propagation.—Johne (No. 50, xix. 1881, p. 273) found the actinomyces adherent to vegetable particles and attached to

FIG. 495.—ACTINOMYCES. Surface-culture on peptone-agar. The colonies are in the form of minute amber-coloured beads which tend to fall off from the surface of the medium into the liquid of condensation and to retain their bead-like character. They have a close resemblance to the colonies of Streptothrix (Fig. 497). (See page 1025.)

FIG. 496.—BACILLUS FLUORESCENS NON LIQUEFACIENS. Surface-culture on peptone-gelatine. The colony is peculiarly dense, its surface somewhat corrugated, and the margin well defined. The organism throws out an emerald-green colouring matter which pervades the culture medium. (See page 974.)

FIG. 497. — STREPTOTHRIX OF EPPINGER. Surface-culture on peptone-gelatine. The colonies take the form of slightly red-coloured beads, resembling those of Actinomyces. (See page 1025.)

FIG. 498.—CLADOTHRIX DICHOTOMA. Surface-culture on peptone-agar. The colonies assume the character of rounded cup-shaped crusts. The organism throws out a brownish-red colouring matter. (See page 974.)

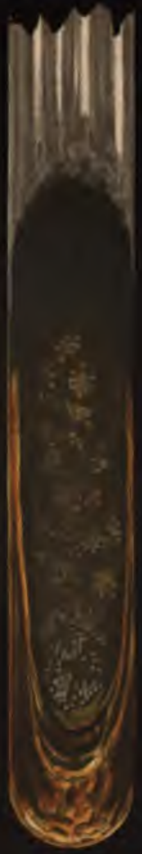


Fig. 495.

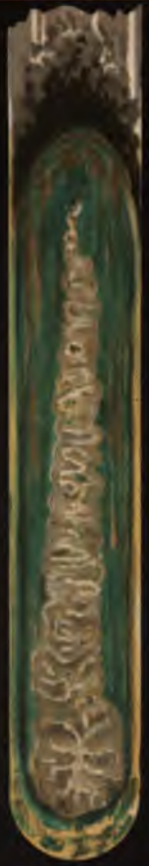


Fig. 496.

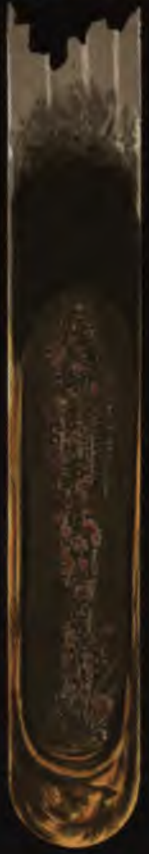


Fig. 497.

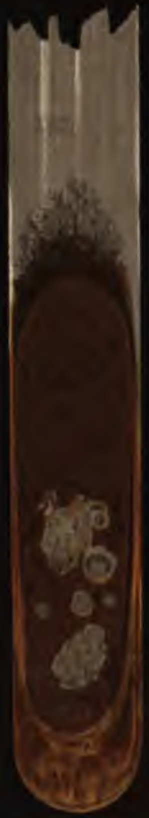


Fig. 498.

R. & R. Clark. Edinburgh

the tonsils of the pig. They have also been discovered adherent to other free surfaces. Sometimes the point of entrance has been a carious tooth, a wound of the skin, or the mucosa of the bronchi.

Israel (No. 50, xxiv. 1886, p. 306) describes a case of the disease in the lung acquired apparently directly by inhalation. The patient, a coachman, had been in the habit of sleeping on straw or hay, and had drunk out of the same trough as his horses. An abscess formed under the left mammilla which increased in size and resolved itself into an ulcer. He became emaciated. The left half of the chest assumed a shrunken appearance, and abscesses, followed by ulcers whose secretion contained abundant ray-fungus, developed upon it. The fungus was also present in the sputum. After death a large cavity was found at the base of the upper lobe. The actinomycotic infiltration had spread through the pleura into the chest wall. The liver, spleen, and intestinal mucous membranes were waxy.

He believes, however (No. 92, xxxiv. 1887, p. 163), that the parasite is not inhaled from the atmosphere, but from the mouth or throat. Teeth with cavities in them act as a nidus for the fungus. He says that he has established the fact by a long series of observations. In one case he found in the lung what he affirms to be a piece of a tooth as large as a lentil. It had the structure of dentine. An organism has several times been detected in the tartar encrusting the teeth and in the crypts of the tonsils, which closely simulates actinomyces. The general belief, however, is that it is nothing more than leptothrix buccalis.

It should be added that, once having taken hold of a tissue or organ, it spreads throughout the body apparently through the agency of leucocytes as carriers (Delépine, No. 192, xl. 1888-89, p. 426).

Literature on Actinomycosis.—**Bollinger**: Centralbl. f. d. med. Wissensch., xv. 1877, p. 481. **Boström** (in Man): Beitr. zur path. Anat. u. allg. Path. (Ziegler), ix. 1890, p. 1. **Bristowe** (Gastro-intestinal): St. Thomas' Hosp. Rep., xiv. 1886, p. 243. **Chiari** (of Intestine): Prag. med. Wochnschr., ix. 1884, p. 93. **Crookshank**: Annual Rep. Agricultural Depart. Privy Council Office, 1888; Trans. VII. Internat. Cong. Hyg. and Demog., 1892, ii. p. 105; *also*, Manual of Bacteriology. **Delépine**: Trans. Path. Soc. Lond., xl. 1889, p. 408. **Eve** (Gastro-intestinal): Brit. Med. Journ., 1889, i. p. 584. **Firket**: Rev. de Med., iv. 1884, p. 276. **Fleming**: Vet. J. and Ann. Comp. Path., xvi. 1883, p. 73 *et seq.* **Hamer**: Ztschr. f. Heilk., xi. 1890, p. 255. **Harley** (Gastro-intestinal): St. Thomas' Hosp. Rep. Lond., xv. 1886, p. 235; *also*, Med.-Chir. Trans., Lond., lxix. 1886, p. 135. **Israel** (Original Article): Arch. f. path. Anat., lxxiv. 1878, p. 15; *also*, Arch. f. path. Anat., lxxxvii. 1882, p. 364; *also* (in Lung), Centralbl. f. d. med. Wissensch., xxiv. 1886, p. 306; *also* (in Lung), Arch. f. klin. Chir., xxxiv. 1886, p. 160; *also* (Cultivation of), Arch. f. path. Anat., xcv. 1884, p. 140. **Kischensky**: Archiv f. exp. Path. u. Pharmakol., xxvi. 1889, p. 79. **Linden**: Aktinomykose, 1892. **M'Fadyean**: Journ. Comp. Path. and Therap., ii. 1889, p. 1. **Pawlowsky and Maksutoff** (Phagocytosis in A.): Ann. de l'Inst. Pasteur, vii. 1893, p. 544. **Pflug** (in lung): Oesterr. Vrtljschr. f. wissensch. Veterinärk., lviii. 1882, p. 13. **Ponfick**: Die Actinomykose d. Menschen, 1882; Berl. klin. Wochnschr., xvii. 1880, p. 660; Arch. f. path. Anat., lxxxvii. 1882, p. 541. **Pusch** (in Lung): Arch. f. wissensch. u. prakt. Thierh., ix. 1883, p. 447. **Wolff and Israel**: Arch. f. path. Anat., cxxvi. 1891, p. 11.

MYCETOMA (*Madura Foot*).

1142. The clinical features of this disease, according to Bocarro (No. 59, 1893, ii. p. 797), are mainly as follows:—A localised tenderness develops at one part of the foot or hand, never, so far as known, on

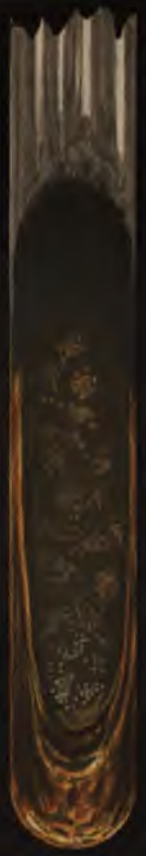


Fig. 495.

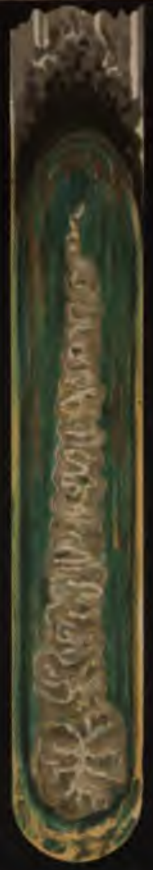


Fig. 496.

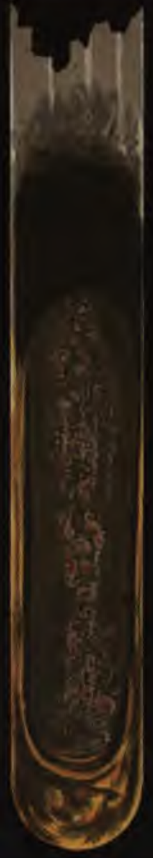


Fig. 497.

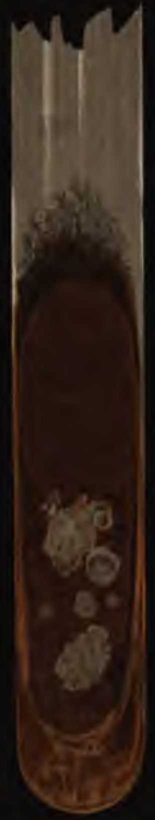


Fig. 498.

R. & R. Clark. Edinburgh.

agar medium. Its cultivation under any circumstances is a matter of difficulty; one tube may show a luxuriant growth, another remain sterile. The best medium is human blood, next rabbit's blood. A convenient medium is gélose mixed with blood. This can be heated to 70° C. without losing its efficiency. The bacillus fails to grow on blood-serum.

To obtain a pure culture Pfeiffer makes an emulsion of sputum with one or two cubic centimètres of bouillon. This is sown on the surface of gélose smeared with blood. The colonies are so small that a pocket-lens may be required for their detection. The difficulty of recognising them is increased by the fact that they possess the transparency of water.

The highest temperature at which the bacillus will grow is 42° C., the lowest 26°-27° C. The optimum is that of the body.

It is aerobic, and a certain humidity is necessary for its maintenance and increase.

Resistance to External Agents.—In sputum, the bacilli preserve their vitality for fourteen days. They are easily destroyed by drying. Colonies are sterilised within twenty-four hours by drying, sputum after forty hours. Heating above 60° C. kills bouillon cultures in five minutes.

Inoculability.—Monkeys and rabbits give positive results, other animals are refractory. By rubbing the bacillus into the nasal mucous membrane of monkeys, or by injecting it into the lung, he called forth symptoms similar to those of human influenza. These observations have been confirmed by Beck (No. 22, 1892; *also*, No. 49, 1892, ii. Ab. 1, p. 10) and Weichselbaum (No. 611, 1892, Nos. xxxii. and xxxiii.; *also*, No. 49, 1892, ii. Ab. 1, p. 10).

Contagion.—The disease is evidently communicated from Man to Man by contagion. The bacillus is abundant in the sputum, more especially in the green-yellow sputum at the deepest part of the crachoir.

Horses suffer from a disease known popularly as "pink eye," a catarrhal affection which disables them for several days, and which is accompanied by conjunctivitis. It has been alleged that this disease of the horse can communicate influenza to Man and *vice versâ*. Although epidemics of equine influenza may have prevailed accidentally in different parts of Europe at the time when human influenza was rampant, yet there is an absence of evidence connecting the occurrence of the one with that of the other.

TUBERCLE.

Sufficient has already been detailed of the morphological characters of the tubercle bacillus, its staining, the localities in which it occurs, and its relationship to the tissues in which it grows (see Index). It remains to indicate briefly the features of its artificial cultivation. The medium on which the bacillus was originally grown by Koch was stiffened blood-serum, and for long it was supposed that it would grow on nothing else. As discovered by Roux, however, the addition of from 5 to 6 per cent glycerine to almost any medium has the effect of rendering that medium quite as suitable for the purpose, if not more so, than blood-serum.

On glycerine-agar it grows in the form of little gray curdled-milk-like patches or spots which tend to become confluent as time goes on (Fig. 501, Coloured Plate). Ultimately a honeycomb sort of surface results (Fig. 502, Coloured Plate), rough, corrugated, and very dry. The spotted or patchy appearance develops in from two to three weeks, but the honeycomb aspect is not visible till several weeks afterwards, sometimes not till months have elapsed.

On glycerine-beef-tea the growth falls down to the bottom of the flask. When shaken up, the sediment rises in clouds which soon subside.

The power of retaining the basic aniline dye in presence of a mineral acid is never so great in an artificial culture as in sputum or in the tissues.

The optimum temperature is that of the body. The bacillus fails to grow a few degrees above or below this.

Literature on Influenza.—**Canon** (Micro-organism): Brit. Med. Journ., 1892, i. p. 129; *also*, Deut. med. Wochnschr., xviii. 1892, p. 28; *also* (I. Bacilli in Blood): Arch. f. path. Anat., cxxxi. 1893, p. 401. **Cornil and Chantemesse**: Bull. Acad. de med., xxvii. 1892, p. 173. **Dieudonné** (Influenza of Horses and its relationship to Human Pneumonia): Deut. mil. ärztl. Ztschr., xxi. 1892, p. 99. **Friedrich**: Arb. a. d. k. Gesundheitsamte, Berl., vi. 1890, p. 254. **Grasset**: Leçons sur la grippe de hiver 1889-90, 1890. **Greenwood**: Practitioner, xlviii. 1892, p. 401. **Jacobi** (Historical): Trans. N. Y. Acad. Med. (1890), 1891, 2 s., vii. p. 61. **Kirchner**: Ztschr. f. Hygiene, ix. 1890-91, p. 528. **Kitasato** (Bacillus): Brit. Med. Journ., 1892, i. p. 128; *also*, Deut. med. Wochnschr., xviii. 1892, p. 28. **Klein** (Bacillus): Brit. Med. Journ., 1892, i. p. 170. **Letzerich** (Bacillus of I.): Ztschr. f. klin. Med., xx. 1892, p. 274. **Pfeiffer**: Deut. med. Wochnschr., xviii. 1892, pp. 28, 465, and 813; *also*, Brit. Med. Journ., 1892, i. p. 128; *also*, Wien. med. Bl., xv. 1892, p. 345; *also*, Ztschr. f. Hyg. u. Infectionskrank., xiii. 1893, p. 357. **Pfeiffer and Beck**: Deut. med. Wochnschr., xviii. 1892, p. 465. **Report by Parsons**, with Introduction by Officers of the Local Gov. Board, 1891. **Ripperger**: Die Influenza, 1892. **Sisley**: Epidemic Influenza, 1891. **Thornbury**: N. Y. Med. Rec., xli. 1892, p. 621. **Williams** (Horse): Vet. Journ. and Ann. Comp. Path., xxxiii. 1891, p. 73. **Wolff**: Die Influenza-Epidemie 1889, 1892.

CHAPTER XCVI

SYSTEMATIC BACTERIOLOGY—(*Continued*)

GLANDERS.

1144. **Definition.**—*A specific disease inoculable upon many of the lower animals, but occurring naturally for the most part in those of the equine race and in Man. It is characterised by the formation of tumours and abscesses in different regions of the body, caused by the presence of a small microphyte, the Bacillus mallei.* The disease runs an acute or chronic course, is very malignant, and usually ends fatally.

Animals affected.—The horse is more often the subject of glanders than any other animal, and when the disease shows itself in Man it has generally been contracted from this animal. The ass does not take it often naturally, but there is no animal more readily inoculated artificially. The cat and guinea-pig can also be easily inoculated. The bovine race are held to be exempt.

Manifestations in Animals.—*In the horse* the mucous membrane of the nose is perhaps more constantly the seat of lesion than any other part. Papules the size of a lentil or larger develop on the mucous membrane, chiefly of the septum nasi. These in course of time suppurate and ulcerate, and from them a glairy or mucopurulent discharge is thrown off which runs from the nostril. In course of time the trachea and lung become infected. The lesion of the trachea is very much like that of the nares, but in the lung, nodules the size of a pea, a filbert, or larger, develop at intervals throughout its substance. These in certain instances may suppurate. They somewhat resemble tubercle nodules, but do not tend to caseate as tubercle nodules do.

The lymphatic glands throughout the body soon become contaminated. Those in the neck are particularly prone to do so. Chains of them can be seen and felt underneath the skin, all in a state of enlargement and induration. The name "glanders" is given to the disease on account of the great enlargement to which the lymph-glands are subject. Tumour masses also show themselves in the skin, and to these the term **Farcy** is usually applied.

In Man the disease manifests itself by the occurrence of abscesses in different parts of the body, some situated deeply, others superficially. Furuncles may form on the face, and be accompanied by more or less œdematous swelling. Irregularly-shaped ulcers are found within the nares. The joints may be swollen and painful, and the whole extremities œdematous from the abscesses located within them.

Examined microscopically, the nodules are essentially fibrous tissue growths, with a greater or less predominance of cellular elements according as the tendency to suppurate is well or ill marked. In the case of the lung the appearances differ in correspondence with whether the nodule examined is primary or secondary. Leclainche and Montané (No. 423, vii. 1893, p. 481) say the spread of the disease through the lung is essentially along the lymph paths. From a central *foyer* secondary nodules radiate very much as in the case of chronic tuberculosis. The central *foyer*, as described by Czoker (ref. by Leclainche and Montané, No. 423, vii. 1893, p. 483), is initiated by a tumefaction, desquamation, and accumulation of the alveolar epithelium. Then there develops a more or less necrosed central area within the infiltrated patch, composed of fatty round cells and dissociated alveolar walls. This central zone of degeneration is limited

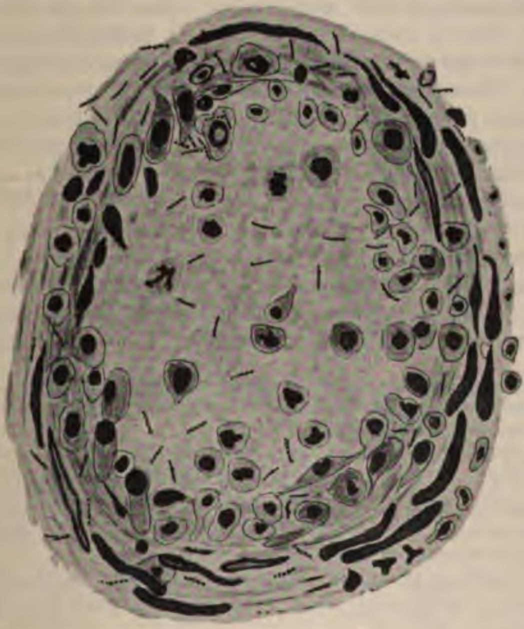


FIG. 582.—PULMONARY GLANDERS. SECTION OF A BRANCH OF THE PULMONARY ARTERY SHOWING THE BACILLI PENETRATING THE WALL.

externally by a compact zone formed of leucocytes. Outside this again there is a third more fibrous layer, constituting as it were a limiting shell.

The Bacillus.—Loeffler and Schütz (No. 93, 1882; *also, Eng. Transl.*, N. Syd. Soc., 1886, p. 387) found fine rods in sections of the lung, liver, and septum nasi which are now proven to be the cause of the disease. They are about the size of tubercle bacilli, and either lie free or are included within cells. They are not found often in the cells constituting the barrier wall of the *foyer*. They are straight, and have a breadth of from 0·2-0·3 μ; rarely they obtain a breadth of 0·4 μ. Sometimes they are in the form of a diplo-bacillus. They colour readily enough with most aniline dyes, but do not retain the colour with Gram's method. The stained bacilli from old cultures sometimes have the appearance of coloured grains arranged in chaplets (Fig. 582). These are the chromatic parts of the bacillus; they stain differently from other parts. Thus with Ehrlich's red, and subsequently with methylene blue, they come out of a red-violet, and with Loeffler's methylene blue they stain violet.

It is easily destroyed by heat; a temperature of 55° C. for ten minutes proves fatal to it. Germicides also readily destroy it. It does not appear to spore.

Staining.—The bacillus can be stained in Ziehl-Neelsen's carbolic fuchsin or carbolic methylene blue, decolorising subsequently with distilled water or with a 2 per cent solution of hydrochloric acid.

Nonievicz (No. 49, 1891, i. p. 281) recommends the following:—

(1) The sections are taken out of alcohol and placed in Loeffler's methylene blue solution[1] for two to five minutes.

(2) They are washed and transferred to the decolorising solution, which consists of 75 parts of a ½ per cent solution of acetic acid and 25 parts of a ½ per cent turpentine-water-solution. The time in which the section lies in this liquid varies in accordance with the thickness of the section. Those which are pretty thick should have from two to five seconds.

(3) The preparations are next washed in distilled water, transferred to the slide, the water removed with blotting paper, and left to dry in the air or gently heated over a spirit lamp.

(4) They are treated ultimately with xylol, and mounted in Canada balsam. The longer they lie in the xylol the clearer they become.

Artificial Culture.—The bacillus grows readily on the surface of gelatine, and does not liquefy it. On a line inoculation of the surface of the gelatine medium the culture assumes the aspect of a perfectly smooth, uniform, and homogeneous single colony (Fig. 507). It is peculiarly slimy or honey-like, of a faint grayish colour, and is without differentiation of surface. The edges are regular, not indented, and the growth spreads out more towards the lower end of the tube than the upper, so that it is somewhat spatula-like in form.

[1] 30 CC. sat. alcoh. sol. meth. blue.
100 CC. potash solution 1 : 10,000 (0·01 per cent).

Cultures on potato assume a light *chocolate* tint (Fig. 506). The colour resembles that of bacillus pyocyaneus grown on the same medium.

Inoculation.—The virulence of the culture does not seem to decrease with age. When inoculated on the nasal mucous membrane of the horse, and on the two shoulders, Loeffler and Schütz (No. 93, 1882; *also, Eng. Transl.*, Syd. Soc.) found that in forty-eight hours the animal showed evidence of high fever. At the points of inoculation there were deep ulcers and the knotted cords of glanders. In eight days there were pronounced clinical signs of glanders. In four weeks the ulcers began to heal, and the animal seemed to recover. On killing it, however, the body was found to be filled with glanders nodules.

White mice appear to be insusceptible, but the common gray mouse takes the disease readily.

Subcutaneous injection or contact of the virus with a wound is the best method of communicating the disease. It can also be conferred by injection of the bacillus into the trachea, but not so surely. Babes (No. 646, p. 23) says that it may also be conferred by rubbing the culture into the skin. The bacillus enters by the hair follicle. It next penetrates through the epithelium, and makes its way into the lymphatic spaces.

An inoculation made through the skin of the horse may induce an eruption of tubercles on the mucous membrane of the nose.

It should be mentioned that the discharge from the nose is highly contagious.

Literature of Glanders.—**Babes:** Arch. de méd. expér. et d'anat. path., iii. 1891, p. 619; *also*, Annales de l'Institut de Path. et de Bactériol. de Bucharest, ii. 1893, p. 18. **Babes and Motoc:** Annales de l'Institut de Path. et de Bactériol. de Bucharest, ii. 1893, p. 63. **Finger:** Beitr. z. path. Anat. u. z. allg. Path., vi. 1889, p. 375. **Finkelstein** (Strauss' rapid Method of Diagnosis): Centralbl. f. Bakteriol. u. Parasitenkrank., xi. 1892, p. 433. **Gamaléia:** Ann. de l'Inst. Pasteur, iv. 1890, p. 103. **Israel:** Berl. klin. Wochnschr., xx. 1883, p. 155. **Leclainche and Montané:** Ann. de l'Inst. Pasteur, vii. 1893, p. 481. **Löffler:** Arbeit. a. d. k. Gesundheitsamt, i. 1886, p. 141. **Löffler and Schütz:** Deut. med. Wochnschr., No. 52, 1882; *see also, Eng. Transl.* N. Syd. Soc., 1886, p. 387. **Nocard** (Inoculation through Skin): Bull. Soc. centr. de méd. vet., viii. 1890, p. 322. **Nonevitch** (Staining of Bacillus): Arch. vet. nauk., St. Petersburg, i. 1890, p. 97. **Rabe** (Histology): Jahresb. d. k. Thierarzneischule zu Hanover, Ber. 9, 12, and 13, 1877-1881. **Schütz:** Journ. Comp. Med. and Surg., vii. 1886, p. 196. **Tedeschi** (Inoculation on Central Nerv. Syst.): Beitr. z. path. Anat. u. z. allg. Path., xiii. 1893, p. 365. **Weichselbaum:** Wien. Med. Wochnschr., 1884, p. 754.

TETANUS.

1145. **Definition.**—*A disease common to most of the higher vertebrates and to Man, characterised by the occurrence of spasmodic contraction of the muscles in different parts of the body.*

Vital Phenomena.—The disease is generally associated with a wound, sometimes nothing of the kind is apparent. The wound is sometimes very small, and is often located on a peripheral part, such as the finger in Man, the foot in horses, etc. Where the wound has been caused accidentally, and where a foreign body such as a splinter of wood, soil, etc., has been retained within it, the danger of the occurrence of tetanus is great. The spasms may affect practically the muscles of the whole body, or it may be only particular groups such as those of the jaw (trismus) or the back. The term *Opisthotonos* is employed when the back is arched backwards, that of *Emprosthotonos* when forwards.

The wound may be in a putrid state or not. The former is the commoner.

Head Tetanus.—A peculiar variety of the disease has been described by Rose (No. 644, i. 2 Ab., p. 86) under the above name. The cases are characterised by a wound in the neighbourhood of the twelfth cranial nerve and by symptoms which in a manner are related to those of hydrophobia, such as spasm of the muscles of the pharynx. There is also paralysis of the portio dura on the side on which the wound is situated. According to Nicolaïer (No. 13, cxxviii. 1892, p. 15) it is due to the same bacillus as ordinary tetanus, and he supposes that the organism elaborates toxic substances which, as in the case of diphtheria, act upon the facialis.

Its Pathology.—Since the days of antiseptic surgery tetanus from being one of the commonest of diseases has become a comparative rarity. The disease has long been held to be organismal in its cause, and to be contagious. Attempts made by Arloing and Tripier to transmit the disease to animals by the inoculation of tetanus pus or blood, however, proved barren. Nocard was also unsuccessful with cerebro-spinal fluid and emulsion of the medulla oblongata. Rosenbach succeeded later on (No. 581, 1886) in communicating the disease to the guinea-pig and rabbit by employing fragments of gangrenous tissue from a tetanus wound. He was also enabled to continue the disease in other guinea-pigs and rabbits from the pus generated in the pocket of skin formed where the fragment of gangrenous tissue had been introduced.

It was Nicolaïer, however (No. 664), who discovered what we now know to be the specific agent in the causation of the malady. He found that different kinds of earth, more especially drift soil in courtyards, etc., contain a bacillus which, when inoculated upon the guinea-pig and rabbit, gives rise to characteristic tetanus. The contractions commence in the limb inoculated and subsequently extend. Death takes place in three or four days. The various organs are free from lesion. If some of the soil itself is introduced into a pocket of skin, the same effects follow. Soil which is sterilised has no effect. The bacillus, curiously, seems to act most efficiently when inserted under the skin on a splinter of wood. The incubation period is about three days.

When a pure culture of the bacillus is employed for inoculation, pus does not develop at the seat of puncture, and the bacilli furnished with spores are found only occasionally. The bacilli, moreover, are confined to the neighbourhood of the wound. The blood is sterile even when inoculated upon the dura mater after trepanation or introduced by venous injection. Mice inoculated on the tail a little distance from its root, do not contract the disease if the tail is amputated one hour afterwards above the point of inoculation. After this time amputation fails to ward off the disease.

The period of incubation in the mouse after inoculation is twenty-four hours, and death takes place in three days. In the rabbit the period of incubation is about three days; in the dog two days; and in the ass three days. Pigeons do not contract the disease readily.

The Bacillus.—Kitasato (No. 581, 1889) first isolated the organism and cultivated it artificially in a pure state. He isolated it from a tetanus wound in Man. Besides Nicolaïer's bacillus the pus utilised contained fifteen other organisms—three anaerobic, five facultative, and seven aerobic. The cultivations of the bacillus of Nicolaïer alone proved effectual in inducing tetanus.

In obtaining a pure culture the pus was sown on stiffened blood-serum and kept at a temperature of 36° for forty-eight hours. The bacillus was thus enabled to spore and to resist the next part of the process. Having assured himself by inoculation that the culture after this time contained the bacillus, he subjected it to a temperature of 80° for three-quarters of an hour, and again inoculated upon animals. They died tetanic. A certain number of the contaminating organisms were thus killed off. Some of the culture, so far purified, was now spread upon gelatine and placed in an atmosphere of hydrogen at a temperature of 20° C. The bacillus grows rapidly in an atmosphere of hydrogen, the remaining organisms of contamination do not. Pure cultures can thus be obtained and transferred to fresh tubes.

Culture.—The media upon which it grows most easily are agar, gelatine, and bouillon if rendered faintly alkaline. A puncture growth on gelatine begins to fructify at a depth of about two finger-breadths below the free surface. It liquefies gelatine slowly and with feeble disengagement of carbonic acid gas. With the addition of 15 to 20 per cent of glucose its growth is hastened. The cultures exhale a characteristic odour.

The *culture colonies* at first are somewhat like those of bacillus subtilis. They have a thick centre and are surrounded by an areola of bristle-like processes extending equally in all directions. This appearance fails later on. The dark centre becomes less and less well marked and finally vanishes; only a few isolated rays are to be noticed, and the colony comes to look like that of a mould.

It increases rapidly at a temperature of from 33° to 38° C., and develops spores after thirty hours' incubation. At a lower temperature the colonies develop later, and sporing takes place only at the end of a week. At from 14° to 16° C. the bacilli take the shape of little straight rods isolated or in long filaments with a slight swelling at one end; but at higher temperatures a round spore develops at one end,

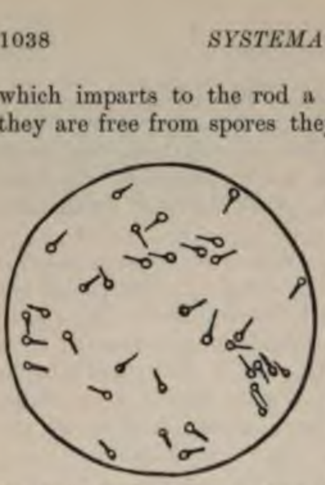


Fig. 583.—Tetanus Bacillus from a Culture on Agar, showing a Spore at the end of each Rod, and giving rise to a Drumstick-like Appearance (after Pfeiffer; × 1000 Diams.)

which imparts to the rod a drumstick-like appearance. So long as they are free from spores they are slightly motile; the movement is best seen at a temperature of 38° C., and disappears as soon as the spores present themselves. They colour with the usual reagents. The spores preserve their vitality for three-quarters of an hour at 80° C., but five minutes of a temperature of 100° C. kills them. A 50 per cent carbolic acid solution kills them only after fifteen hours. A 1 per cent mercury bichloride solution destroys them in three hours, or in thirty minutes after the addition of 5 per cent hydrochloric acid.

It should be mentioned that the formation of a spore at one end is not peculiar to the bacillus of tetanus. A drumstick organism has also been found by Bienstock in the intestine. It decomposes fibrine, giving rise to leucine, tyrosine, carbonic acid, water, and ammonia.

Literature on Tetanus.—**Arloing and Léon Tripier:** Arch. de Physiol. norm. et path., iii. 1870, p. 235. **Behring and Frank** (Experimental on Poison): Deut. med. Wochnschr., xviii. 1892, p. 348. **Bonome:** Fortschr. d. Med., v. 1887, p. 690. **Bossano:** Recherches expérimentales sur l'origine microbienne du tétanos, 1890. **Brieger:** Bericht d. deut. chem. Gesellsch., xix. 1886, p. 3119. **Brieger and Fraenkel:** Berl. klin. Wochnschr., xxvii. 1890, p. 241. **Brunner** (Excretion of Poison): Deut. med. Wochnschr., xviii. 1892, p. 427. **Bruschettini** (Shedding of Poison by Kidneys): Deut. med. Wochnschr., xviii. 1892, p. 348. **Casali** (Tizzoni-Cattani Treatment with Antitoxin): Centralbl. f. Bakteriol. u. Parasitenk., xii. 1892, p. 56. **Demme:** Beitr. zur path. Anat. d. Tetanus, 1859. **Faber** (Pathogenesis): Berl. klin. Wochnschr., xxvii. 1890, p. 717. **Harger** (Recent Investigations on Treatment): Journ. Comp. Med. and Vet. Arch., N. York, xiii. 1892, p. 241. **Kitasato:** Allg. Wien. med. Ztg., xxxiv. 1889, p. 221. **Kitt** (Tetanus Inoculation): Centralbl. f. Bacteriologie u. Parasitenk., vii. 1890, p. 297. **Kyle** (Pathology of Tetanus): Therap. Gaz., Detroit, viii. 1892, p. 88 *et seq.* **Lecourt** (Equine Origin of T.): Compt. rend. Soc. de biol., v. 1888, p. 745. **Marchesi** (Diffusion of Bacillus in Soil): Ann. d. Ist. d'ig. sper. d. Univ. di Roma, ii. 1892, p. 47. **Nicolaier:** Beitr. z. Aetiol. d. Wundstarrkrampfes, Inaug.-Dissert., Gött., 1885; *also*, Zeitschr. f. Hygiene, 1888, p. 244 *et seq.*; *also* (Etiology of Head-Tetanus), Arch. f. path. Anat., cxxviii. 1892, p. 1. **Nocard:** Recueil de Méd. vét., iv. 1887, p. 617. **Peiper:** Deut. Arch. f. klin. Med., xlvii. 1890-91, p. 183. **Perron:** De la nature infectieuse du tétanos, 1888. **Rénon** (Two cases treated by Antitoxic Blood): Ann. de l'Inst. Pasteur, vi. 1892, p. 233. **Ricochon** (Equine Origin of T.): Compt. rend. Soc. de biol., v. 1888, p. 788. **Rietsch** (Experimental): Compt. rend. Acad. d. sc., cvii. 1888, p. 400. **Schütz** (Immunisation of Horses against Tetanus): Ztschr. f. Hyg. u. Infectionskrankh., xii. 1892, p. 58. **Shakespeare** (Infect. Nature): Med. Press and Circ., xliv. 1887, p. 315. **Solly:** St. Thomas' Hosp. Rep., xx. 1892, p. 393. **Tizzoni, Cattani, and Baquis** (Bacteriological Researches on T.): Beitr. z. path. Anat. u. z. allg. Path., Jena, vii. 1890, p. 569. **Tizzoni and Cattani** (Immunity against Tetanus): Riforma med., viii. 1892, pt. i., p. 554; *also*, Deut. med. Wochnschr., xviii. 1892, p. 394. **Vaillard** (Immunity against Tetanus): Ann. de l'Inst. Pasteur, vi. 1892, p. 224. **Vaillard and Rouget** (Etiology): Ann. de l'Inst. Pasteur, vi. 1892, p. 385.

RABIES AND HYDROPHOBIA (*lyssa*, fr. *λύσσα*, *canine madness*).

1146. Rabies is a disease occurring mostly in the canine, less frequently in the feline race. During the progress of the malady a specific virus is engendered in the saliva of the animal which, when implanted in a laceration of the skin or an abrasion of the cuticle, conveys the disease to other animals and to Man. In the latter case the disease is known as Hydrophobia (ὕδωρ, water, and φοβέω, I fear). After a prolonged incubation period the disease begins to manifest itself by pain in the bitten part, excitement, feverishness, inability to swallow liquids, and great prostration. It invariably terminates fatally with a tendency in the lower animals to bite (Williams).

There is a variety in the dog known as **dumb-rabies** in which, over and above the ordinary symptoms, the jaw drops from paralysis of its muscles, and a similar motor paralysis occurs in the muscles of the palate. It gets its name from the animal being unable to bark or howl.

The stomach of the animal is found to contain quantities of foreign matters, such as straw, stones, etc.

The pathology of this disease is quite unknown. With the exception of a minute vesicle which occasionally forms on each side of the under aspect of the tongue in Man, and which may ulcerate, there is no evidence of gross anatomical lesion. An accumulation of small round cells in the neighbourhood of the small blood-vessels of the central nervous system, more particularly of the medulla oblongata and spinal cord (Coats, No. 604, p. 571), has been noticed.

So far as we know, it is always communicated from one animal to another; it apparently does not arise without some previous living source of contagion. There seems to be almost no limit to the animals which may fall victims to it when bitten. Thus Man, the monkey, dog, wolf, fox, cat, rabbit, guinea-pig, ox, horse, sheep, skunk, and many others widely separated in genealogical history, have all shown their susceptibility to it.

In Man the incubation period extends from four to six weeks. It is followed by the stage of invasion, which is succeeded by that of excitement, to terminate in about four days after the advent of the initial symptoms in the collapse of the individual. During the progress of the disease the most evident symptom is that of increased reflex excitability. So great is this that a draught of cold air or the glittering of a bright object is sufficient to throw the individual into tetanic convulsions. The pharyngeal muscles are sometimes so firmly contracted that the individual is unable to swallow even a draught of water, hence the term *hydrophobia*.

Pasteur's preventative treatment of the disease is referred to under Immunity from Disease (see Sect. 1128).

Literature on Rabies and Hydrophobia.—**Babes:** Ann. de l'Inst. Pasteur, ii. 1888, p. 394; Arch. f. path. Anat., cx. 1887, p. 562. **Babes and Cherchez:** Ann. de l'Inst. Pasteur, v. 1891, p. 625. **Fleming:** Vet. Journ. and Ann. Comp. Path., xxxiii. 1891, p. 153. **Fol:** Comp. rend. Acad. d. Sc., ci. 1885, p. 1276. **Hime** (Pasteur's Antirabic Inoculations): Lancet, 1892, i. p. 1070. **Nocard and Roux:** Ann. de l'Inst. Pasteur, ii. 1888, p. 341. **Pasteur:** Ann. de l'Inst. Pasteur, i. 1887, p. 1. **Report by Select Committee House of Lords on Rabies in Dogs,** 1887. **Roux** (Inoculation against): Wien. med. Presse, xxxii. 1891, p. 1325. **Roux and Chamberland:** Ann. de l'Inst. Pasteur, ii. 1888, p. 405. **Viala** (Causes of Attenuation of Sp. Cords): Ann. de l'Inst. Pasteur, v. 1891, p. 695.

ANTHRAX (*Charbon*).

1147. **Definition.**—*An extremely fatal specific contagious disease, due to the Bacillus Anthracis, and common to a large number of the mammalia and Man.*

The disease apparently has existed from the remotest times. It was undoubtedly known to the ancients, and in the seventeenth and eighteenth centuries appears to have spread in an epidemic form over several parts of Europe. At the present time it is endemic in Siberia, France, Hungary, and Italy, and is becoming more so in this country than previously was the case.

The animals chiefly affected are the sheep, ox, horse, guinea-pig, rabbit, and in a limited measure the pig. The dog, the goat, and the Algerian variety of sheep seem to be in great part proof against the disease. The young rat can be inoculated, but the adult gray and white rats are practically immune. The mouse is probably more susceptible than any other animal. The frog is also immune in its natural state, but when its temperature is raised apparently can also be inoculated. Birds as a rule are naturally insusceptible.

Features of the Disease.—It assumes many outward garbs, indeed so many that the demonstration of the presence of the bacillus is the only reliable criterion of diagnosis. In the lower animals there is usually an absence of external manifestation so far as actual lesion is concerned. The animal may drop suddenly and die in a few hours without suspicion of having been previously ill.

In Man alone is there a characteristic external lesion, and it corresponds with the point of inoculation. The disease is conveyed to Man from the lower animals, and generally shows itself in slaughterers, or in those engaged in dressing hides or the preparation of wool. The local manifestation is known as **malignant pustule.** Besides the skin there are other two channels through which it may be communicated, namely, the respiratory and the alimentary tracts. What is known as **Woolsorter's Disease** has been shown by Greenfield, Buchner, and others to be anthrax communicated by one or the other of these channels of invasion. An **anthracoid pneumonia** may be excited by the presence of the bacillus in the lung; or malignant-pustule-like infiltrations may occur upon the coats of the intestine. Sometimes, however, the latter are metastatic in their origin, and are to be regarded simply as evidence of the organism being widely spread abroad in the blood. At other times they seem to be due to ingestion of the spores. The bacilli are destroyed evidently in the stomach; they fail to pass that organ. It is said that the cause of their destruction is the hydrochloric acid contained in its secretion. This, however, would appear to be negatived by Drymont's observations, to the effect that anthrax spores retain their virulence after lying in a 1 per cent solution of hydrochloric acid for a period of forty-eight hours. The amount of hydrochloric acid in the gastric secretion is much less than this. The organism may be found, nevertheless, in the wall of the stomach.

The **disease of rag-pickers** (*Hadernkrankheit*) in Germany is sometimes alleged to be anthrax. There is, however, difference of opinion on this point, some observers looking upon it as malignant œdema.

Of all methods of artificial communication, that of inoculation by introduction of the virus into a pocket of skin seems to be most effectual. On being swallowed the spores may fail to occasion the disease. When sprayed into the atmosphere and inhaled by animals they sometimes take, at other times fail to do so (Buchner). Injection of the organism into the trachea seems to be a more ready method of communicating it (Muskathlüth); injection into the circulation or into the peritoneal cavity seldom fails.

In Man.—When inoculated upon the skin of Man, as just said, it induces the formation of what is known as **malignant pustule.** At the point of introduction there shows, within a few hours, a little red spot like that resulting from the bite of an insect, followed in course of time by a minute vesicle. The parts in the immediate vicinity may become infiltrated with inflammatory effusion; they are red, hard, and brawny. The tissues around this are probably sound, but sometimes the inflammatory focus of swelling may be encompassed by a rose-red areola, or the redness may spread over an entire limb. The lymphatics of the limb may be red and inflamed. The affected area next becomes gangrenous and, possibly, black coloured. Cutting into it is unattended by pain. Crops of secondary vesicles show themselves round the primary focus, and when so the chains of lymphatics become involved as above. As soon as the epidermis gives way the infiltrated area begins to suppurate, pus is discharged, and the mass sloughs.

Examined microscopically, the bacillus is found to be most abundant in the papillary layer of the skin. The epidermis is usually free from it, and it decreases in frequency in the deeper layers of the skin and subcutaneous areolar tissues. The bacillus, however, is, in the large majority of cases, limited in its distribution to the infiltrated area. As a rule, it is absent from the blood, and in this respect the disease of Man differs from that of the lower animals. A barrier of small round cells gathers round the focus of inflammation and, it is said, limits the spread of the bacillus. When the organism is inoculated on the skin of animals such as the mouse, there is no such local reaction. Those cases where the bacillus remains localised usually recover. The slough separates and the part cicatrises. Such a happy issue, however, is not by any means invariable. In certain cases the bacillus passes the protective barrier and ramifies in the blood. When this is the case the individual usually dies.

So circumscribed is the area containing the bacilli that local excision, the application of the cautery, or strong germicides may be effectual in eradicating the disease.

On the advent of suppuration staphylococci and streptococci make their appearance in the part. It is considered that they, not the anthrax bacilli, account for the suppuration. They are not seen previous to the time when the epidermis gives way.

State of Internal Organs.—In animals the internal organ which shows most evident lesion is the spleen. It becomes swollen and turgid, and huge apoplexies are effused into its substance. The term **splenic fever** or **splenic apoplexy** is sometimes applied to the disease in accordance with this. The other organs may not show any very marked departure from their natural state. The bacilli, however, accumulate in them more than in the blood generally. The capillaries of the lung, liver, and kidney are choked with them, while they pervade the splenic pulp. In the kidney, the vessels of the glomeruli are those in which they are most abundant. They appear to be sifted out of the renal blood by these and to accumulate within them (Fig. 585).

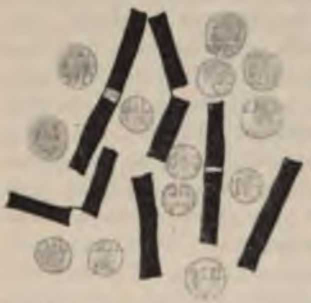


FIG. 584.—ANTHRAX IN BLOOD OF THE MOUSE, SHOWING THE SQUARE-CUT AND TRUNCATED ENDS OF THE BACILLI. SEVERAL BLOOD CORPUSCLES LYING AROUND THE BACILLI ($\frac{1}{12}$ oil imm. Crouch, Oc. 4, Hartk.; vesuvin staining).

The Bacillus.—Pollender generally gets the credit of discovering it; he is said to have recognised it in the year 1849. But Rayer, Brauell, and Davaine became familiar with it all about the same time (see Bibliog.). Being immobile, the bacillus was mistaken in bygone times for something of a crystalline nature. It was Davaine who showed the relationship of the organism to the disease.

It is a straight or somewhat irregularly outlined rod measuring from 5 to 20 μ long by 1 to 1·5 μ broad. The diameter differs according to the medium it is grown upon. The individual bacilli in the blood are apart or in couples. They are broad at each end, truncated, and slightly cupped, so that when they are united in couples the cup-shaped ends enclose a lenticular space. The ends are also sharply cut off, not rounded (Fig. 584). As just remarked, they are also immobile.

These features serve to distinguish it from any other bacillus. It must be remembered, however, that in order to see the above points it is necessary to examine the organism in fresh blood unstained, or stained in vesuvin or Bismarck brown. When stained in gentian-violet or fuchsin and clarified, the capsule is not brought out well and the ends appear rounded (Fig. 576). It is the capsule which imparts the truncated square-cut features to the ends. The advanced forms are always immobile. Those which are younger have been said by Toussaint and Ewart to be slightly mobile. The bacillus stains with basic aniline dyes, and is not decolorised by Gram's process, provided the preparation is not left too long in the decolorising iodine solution.

In the blood, the organism always exhibits the character of a bacillus, but when cultivated artificially it passes through the other stages of its life history. These are the elongation into threads and the development of spores. The threads consist of long rods jointed together. They interlace in such a manner that they become woven into a tangled mass or felt-work of extreme complexity.

Its Culture.—The organism is aerobic, but not exclusively so. The deep part of a puncture culture grows luxuriantly. It fails to grow below 12° C. or above 45° C. The medium should have a neutral reaction or be faintly alkaline. The growth is retarded if the reaction is acid.

It flourishes on a variety of media. The most distinctive growth is seen *on agar* or *glycerine-agar* kept at a body temperature, and always most characteristically when taken fresh from the blood. *In a puncture inoculation*, the culture spreads along the entire course of the needle. *On the surface*, it spreads out in a delicate gray film, but along the needle track throws out numbers of ray-like processes or arms into the surrounding medium (Fig. 504). At the tip of the needle-line a stellate bunch of these is sometimes seen. In gelatine kept at an ordinary temperature the same appearance can be recognised, but is not so evident as when the culture is made in agar and at a body temperature. The bacillus liquefies the gelatine, nearest the surface first, spreading equally downwards afterwards.

On potato the growth assumes the appearance of a gray silky film which in a manner is typical. *In bouillon* the organism falls down to the bottom of the vessel in a cloudy precipitate. *On stiffened blood-serum* nothing very remarkable is noticed, unless the fact that the culture slowly liquefies it.

The colonies on plate cultures at first have a somewhat sharp border, but gradually begin to assume a wavy appearance, with innumerable tortuous branches coming off from the margin almost like the colony of a mould.

Sporing.—The organism spores only in presence of free oxygen; it does not tend to spore in the living body. The medium most favourable for sporing is *potato*, and the best temperature is 30° C. It will not spore below 24°-26° C. (Koch, 18° C.). When cultivated under proper conditions spores develop within twenty-four to forty-eight hours. A clear speck or spot appears in the protoplasm of a thread, usually on either side of a joint (Ewart, No. 9, xviii. 1878, p. 164). This enlarges, becomes provided with a double membrane, and finally is discharged by the members of the thread giving way.

When matured the spores are highly refractile bodies of oval shape which do not readily stain with ordinary aniline dyes. If they are coloured by them the stain is lost by Gram's method. They can, however, be coloured differentially by several methods (see vol. i. p. 134).

They are very resistant to most agents having a germicidal action.

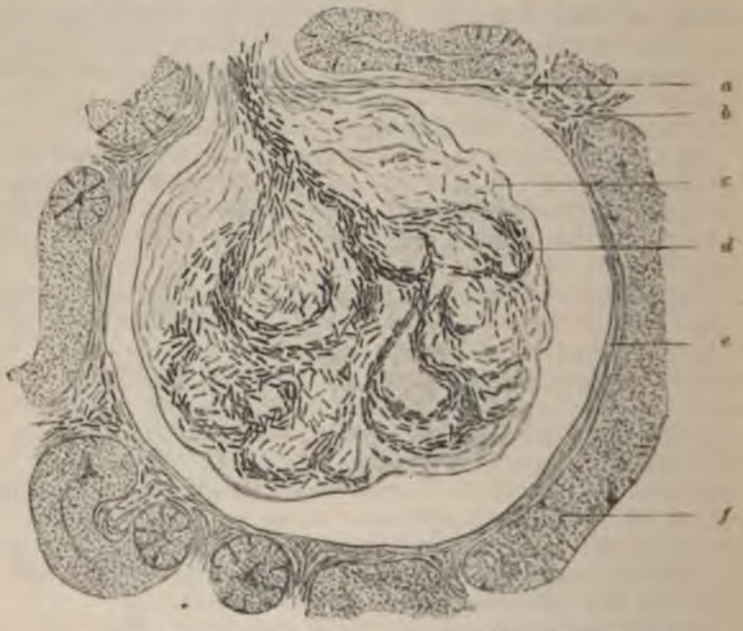


FIG. 585.—ANTHRAX BACILLUS IN A GLOMERULUS OF KIDNEY (×300 DIAMS.)

(*a*) Vas afferens choked with the bacillus; (*b*) intra-tubular capillaries full of the organism; (*c*) the glomerulus; (*d*) capillaries of same injected with the bacillus; (*e*) Bowman's capsule; (*f*) neighbouring tube (Gram's Method and Clarified).

Thus they are killed by dry heat only after exposure for three hours to a temperature of 140° C., while the bacillus perishes after one and a half hours at a temperature of 100° C. The spores are killed when boiled for a few minutes, the spore-free organism after being exposed to a moist atmosphere at a temperature of 55° to 60° C. for the same time. The spores are not destroyed in putrid substances after being mixed with them for months; the bacilli, on the other hand, are very readily destroyed by putrid surroundings. It is generally held to be the carbonic acid developed in process of putrefaction which is the lethal agent. The bacilli are very susceptible to the noxious influence of this gas, the spores are uninfluenced by it. The spores are readily destroyed by bright sunlight.

Life History.—There are three distinct phases in its development, namely, the *rod stage*, the *spore stage*, and the *thread stage*. Starting with the rod as found in the blood, it is seen on cultivation to elongate into a thread. Spores show themselves within this, which on being liberated again elongate into rods and thus complete the life-history cycle. In elongating, the spores at first lose their sparkling, highly-refractile character, probably by the absorption of water. A projection of the contents takes place at one side. The exosporium or outer capsule gives way and the spore contents protrude, covered by the endosporium. These then elongate into a rod. The exosporium may remain adherent for some time to the rod.

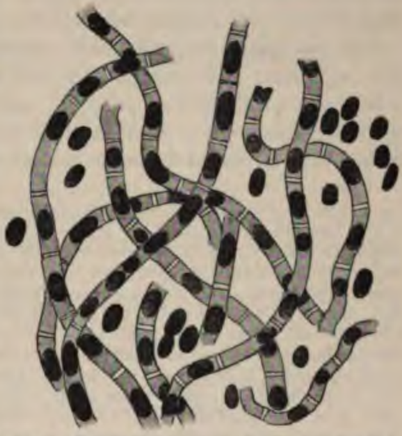


FIG. 586.—CULTURE OF ANTHRAX, SHOWING THREADS CONTAINING SPORES. MANY OF THE SPORES ARE ALSO LYING FREE ($\frac{1}{12}$ homog. imm. Crouch, No. 4, Oc. Hartk.; doubly stained, the spores with fuchsin, the threads with methylene blue).

Sources of Contagion.—Cattle and sheep usually acquire the disease through becoming infected by the spores. The spores are resident on herbage, and, taken into the alimentary canal, they gain entrance to the circulation through the intestine. It is generally supposed that the organism may grow as a saprophyte on dead vegetable matter. Further evidence of this, however, would be necessary before concluding that it is so. More probably the spores are derived from the dejecta of infected animals, from shed blood, or from the carcases of animals which have died from the disease. The spores develop in the blood and tissues readily enough if exposed after death. From these sources they become attached to herbage or buried in the soil, and from time to time are consumed by fresh hosts.

Pasteur's experiments go to show that, even when the carcases of animals dead of anthrax are buried at a depth of 7 feet, the grass grown over the graves may prove a source of contagion to animals feeding upon it something like two years afterwards. He supposes that the **earthworms** bring the spores to the surface, and that they are spread broadcast through their dejecta. He stated, in confirmation of this, that the squirms of the earthworms found in the soil over the graves contained anthrax spores, and that these were capable of communicating the disease to guinea-pigs. The earthworm descends deeply in warm weather, and brings up earth to the surface in its alimentary canal. Darwin found that a depth of more than 3 inches of this worm-mould had accumulated on the surface in a space of fifteen years.

Flies and **insects generally** have been suggested as a means of communicating the disease, but there is no very direct evidence of this being the case.

The danger from water seems to be very slight, although the experiments of Frankland and Marshall-Ward (No. 149, liii. 1893, p. 164 *et seq.*) appear to show that neither in the form of bacilli nor of spores is the organism destroyed forthwith when placed in water. The spores may retain their vitality in water for a matter of months.

It used to be supposed that the **placenta** acted as a perfect filter of the organism. The fœtus was held to be always free from the bacillus when the mother was infected. Further evidence has gone far to disprove this. It is said that, in some instances, the fœtus has been found contaminated from the blood of the mother.

Literature on Anthrax.—**Bollinger**: Centralbl. f. d. med. Wissensch., x. 1872, p. 417. **Brauell**: Arch. f. path. Anat., xi. 1857, p. 132; *Ibid.*, xiv. 1858, p. 432. **Buchner** (Cause of Spore Formation): Sitzungsb. d. Gesellsch. f. Morphol. u. Physiol. in München, vi. 1891, p. 87; *also*, Ueb. d. exper. Erzeugung d. Milzbrandcontagiums aus d. Heupilzen, 1880; *also*, Arch. f. path. Anat., xci. 1883, p. 410. **Chauveau**: Rev. mens. de méd. et chir., iii. 1879, p. 849; *also* (Resistance of Algerian Sheep), Compt. rend. Acad. de Sc., xc. 1880, pp. 1396, 1526; *Ibid.*, xci. pp. 33, 148, 608, 648. **Davaine**: Compt. rend. Soc. de biol., v. 1863, p. 149; *also*, Bull. Acad. de Méd., xxxv. 1870, p. 471; *Ibid.*, ix. 1880, p. 757. **Ewart**: Quart. Journ. Mic. Sc., xviii. 1878, p. 161. **Greenfield**: Proc. Roy. Soc. Lond., xxx. 1880, p. 557; Brit. Med. Journ., 1881, i. p. 3 *et seq.* **Klein**: Rep. Med. Off. Health to Local Gov. Board, 1881; *also*, Practitioner, 1884. **Koch**: Mitth. a. d. k. Gesundheitsamt, i. 1881, p. 49. **Kostjurin** (Cure by Products of Putrefaction): Centralbl. f. Bakteriol. u. Parasitenkrank., x. 1891, pp. 553, 599. **Momont** (Action of Desiccation, Air, and Light on): Ann. de l'Inst. Pasteur, vi. 1892, p. 21. **Phisalix** (Influence of Heat on Sporing): Arch. de physiol. norm. et path., v. 1893, pp. 217, 257. **Pollender**: Vrtljschr. f. gerichtl. u. öff. Med., viii. 1855, p. 103. **Rayer**: Mem. de la Soc. de Biol., ii. 1850, p. 141. **Toussaint**: Compt. rend. Acad. d. sc., lxxxv. 1877, p. 415; *Ibid.*, p. 1076; *Ibid.*, lxxxvi. 1878, p. 725; *Ibid.*, xci. 1880, p. 135; Vet. J. and Ann. Comp. Path., xi. 1880, p. 149. **Ward** (Action of Light on): Proc. Roy. Soc., lii. 1892-93, p. 393; *also*, *Ibid.*, liii. 1893, p. 23. **Weyl** (Immunity): Ztschr. f. Hyg., xi. 1891-92, p. 381. **Wissokowicz**: Fortschr. d. Med., x. 1892, pp. 411, 451. See also Literature under "Attenuation of Virus," Chap. IX.

SYMPTOMATIC ANTHRAX.

1148. This is a disease of cattle which for long was confounded with true anthrax. Both are bacillary diseases, but the bacillus of the one has no connection with that of the other. The bacillus in the case of this disease is known as the **B. Chauvaei.** It is smaller than that of true anthrax.

The disease, unlike true anthrax of the bovine race, is characterised by a local lesion at the point of inoculation. This is usually situated on a hind quarter, and consists in a huge carbuncle-like swelling. In course of time the infiltrated part becomes gangrenous and sloughs very much as true anthrax carbuncle does in Man. During the time that the gangrene is developing much gas is evolved, so that the slough becomes emphysematous and crackles when touched. The swelling, at first painful, becomes absolutely painless in the gangrenous stage. The animal exhibits signs of fever, muscular rigidity, trembling, etc., followed by collapse and death. Curiously, true anthrax and symptomatic anthrax may affect members of the same herd of cattle simultaneously, a coincidence which probably had much to do with their supposed identity.

The disease has been studied by Arloing and by Cornevin and Thomas, and they conclude that, in its pathology, it resembles a septicæmia more than anthrax does. The spleen and liver are found to be almost normal and the blood is little changed.

The organism takes the form of straight rods 1·5 to 5 or 6 μ long by ·5 to 1 μ broad. It occurs isolated or in couples. It is very mobile, a feature which at once serves to distinguish it from true anthrax. It is also a true anaerobe. Many of the rods enclose spores, so that the rods come to have a swollen, irregular, or fusiform appearance. It grows readily on veal bouillon and on glycerine-agar (gélose). During the time of growth it evolves much gas, and the culture has a penetrating acid odour. It liquefies gelatine. The virulence continues to the third generation; after this time the organism becomes quite innocuous. The virulence returns, however, if a little lactic acid be added. It is alleged that the lactic acid acts by being negatively chimiotaxic, and so preventing the approach of phagocytes.

The organism is found, as a rule, in the carbuncle and its neighbourhood alone, and not in the blood. In some instances, however, it may appear in the blood in small quantity after death.

RELAPSING FEVER.

The disease is characterised by the rapid onset of feverish symptoms, great sweating, pains in the joints, etc., ending in a crisis on the fifth to the seventh day. The individual remains well up till the twelfth or seventeenth day, usually the fourteenth, when a relapse occurs. Several relapses may follow the first.

As discovered by Obermeier (No. 50, 1873, p. 145), the disease is accompanied by, and, as later researches have shown (Weigert, Lebert, Heydenreich, Carter, etc.), is due to the presence of a spirillum in the blood, the Spirochæta Obermeieri. The said organism is a long continuous thread-like body, showing many curves and lying singly or associated in clusters (Fig. 587). The clusters sometimes include coloured and colourless corpuscles, and thus constitute an embolus-like mass. In length it is from one and a half to six times that of the long measurement of a blood-disc, and has progressive screw-like movements. These movements may continue for one to eight hours after removal from the body.

It stains readily with basic aniline dyes, but parts with its colour by Gram's process. It has not as yet been cultivated artificially.

Obermeier failed to communicate the disease to animals, but Carter and others have succeeded in conferring it by inoculation on the monkey. It is said that this is the only animal which is susceptible.

Spirochæta denticola is found abundantly in the mouth and nose of healthy individuals. It is quite innocuous.

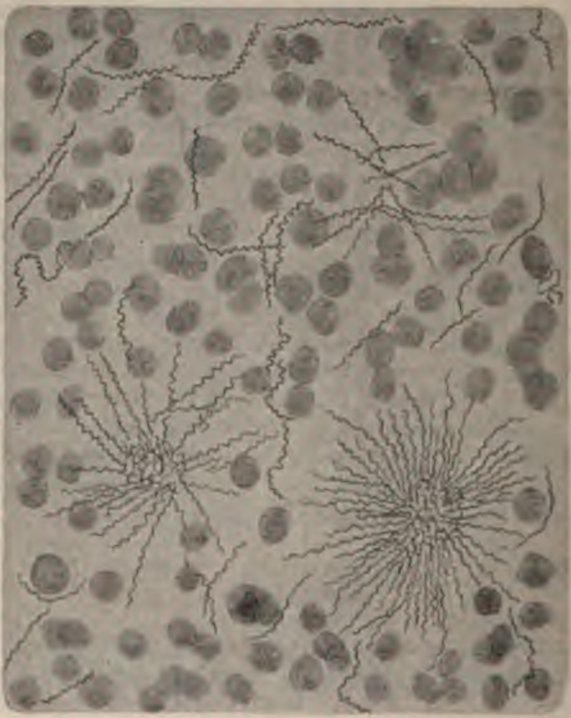


FIG. 587.—SPIROCHÆTA OBERMEIERI INOCULATED ON MONKEY AFTER REMOVAL OF THE SPLEEN (after Soudakewitch).

SARCINÆ (*sarcina*, a package).

1149. Sarcinæ occur in many different situations, and are abundant in air and water, and in dust of all kinds. Sarcina lutea is very common as an atmospheric impurity. Their artificial cultures are usually brilliantly coloured.

The Sarcina ventriculi discovered by Goodsir (No. 19, lvii. 1842, p. 430; *also*, Anat. Mem., 1888, ii. p. 351) is the one perhaps of most pathological importance, from the fact that it so often grows on the contents of the stomach where there is any obstruction at the pylorus, where the contents have difficulty in moving onwards, and where consequently the organ becomes dilated. It confers a somewhat rust-brown colour upon the contents.

The parasite is composed of round coccus-like bodies held together in groups of four or multiples of four by a little intermediate cement substance. Each member divides in three directions. The colonies have a package- or wool-pack-like appearance, hence the designation sarcina. The cocci are about 2·5 μ in diameter. The organism grows with some difficulty on neutral media. On gelatine, by thirty-six hours, it has developed little round colonies of a yellow colour, whose growth, for some unknown reason, soon becomes arrested. It does not liquefy gelatine.

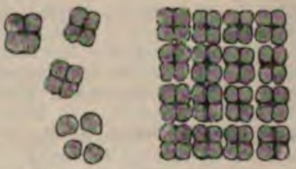


FIG. 588.—SARCINA VENTRICULI (Goodsir).

MICROCOCCUS TETRAGENUS.

1150. This is a minute organism of the sarcinous type discovered by Gaffky (No. 92, xxviii. 1882, p. 500) in phthisical sputum. It is especially abundant in that from phthisical cavities. It is also found in abscesses. It is round and the members are associated in tetrads. Each member is about 1 μ in diameter. The method of cleavage is like that of sarcinæ, but takes place only in two directions. The tetrads are often enveloped in a gelatinous membrane.

It grows on all media and is aerobic. The colonies have a brilliant white porcellanous aspect and do not liquefy gelatine.

White mice are very susceptible to it. They die rapidly after inoculation and the blood is found to contain the organism. Some animals are refractory.

Gelatine puncture inoculations give rise to disc-like colonies superimposed the one over the other, and ending above in a milk-white or faint yellow button-shaped protuberance.

GENERAL LITERATURE ON BACTERIOLOGY (TEXT-BOOKS, ETC.)

Abbott: The Principles of Bacteriology, 1892. **Albrecht** (Development of Spirochæta Obermeieri): Deut. Arch. f. klin. Med., xxix. 1881, p. 77. **Arloing** (Relationship of Bac. Coli Comm. and Bac. of Eberth): Tr. VII. Internat. Cong. Hyg. and Demog., 1892, ii. p. 272. **Ball:** Essentials of Bacteriology, 1893. **de Bary:** Lectures on Bacteria (*Eng. Transl.*), 1887; *also*, Comp. Morph. and Biol. of the Fungi, etc., *Eng. Transl.*, 1887. **Baumgarten:** Lehrbuch d. path. Mykologie, 1886. **Berthelot** (Micro-Organisms which fix Azote): Compt. rend. Acad. d. sc., cxvi. 1893, p. 842. **Billroth:** Coccobacteria septica, 1874. **Brefeld:** Botanische Untersuchungen üb. Schimmelpilze, 1872-83. **Buchner** (Influence of Light on Bacteria): Arch. f. Hyg., xvii. 1893, p. 179. **Canestrini:** Batteroiologia, 1890. **Chantmesse and Widal** (Differentiation between Bac. Comm. Coli and Typhoid): Ann. d'hyg., xxvii. 1892, p. 97. **Cohn:** Beiträge z. Biologie d. Pflanzen. **Cornil and Babes:** Les Bactéries, etc., 1890. **Crookshank:** Manual of Bacteriology, 1890. **Dallinger:** Res. into Origin and Development of Minute and Lowly Life Forms, 1877. **Dangeard** (Histological Structure of Yeasts): Compt.

rend. Acad. d. sc., cxvii. 1893, p. 68. **Discussion on Relations of Minute Organisms to certain Specific Diseases:** Tr. Intern. M. Cong., 1881, i. p. 323. **Eisenberg:** Bakteriologische Diagnostik., 1886; *also, Eng. Transl.*, 1892. **Engelmann** (Biology of Schizomycetes): Arch. f. d. ges. Physiol., xxvi. 1881, p. 537. **Ernst** (Gas-forming Anaerobe in Human Body and Relation to "Schaumleber"): Arch. f. path. Anat., cxxxiii. 1893, p. 308. **Fol:** Les Microbes, 1885. **Foth** (Staining of Spores): Centralbl. f. Bakteriol. u. Parasitenkrank., xi. 1892, p. 272. **Fraenkel:** Grundriss d. Bakterienkunde, 1887; *also, Eng. Transl.*, 1891. **Fraenkel and Pfeiffer:** Atlas der Bakterienkunde, 1889. **Frankland (G. C.) and Frankland (P. F.)** (Organisms of Water and Soil): Ztschr. f. Hygiene, vi. 1889, p. 373. **Gessard** (Fluorescence in Microbes): Ann. de l'Inst. Pasteur, vi. 1892, p. 801. **Günther:** Einführung in das Studium d. Bakteriologie, 1891. **Haerén** (Power of Soil in destroying Bacteria): Helsovännen, Stockholm, vi. 1891, pp. 83, 98. **Hallier:** Die Pflanzlichen Parasiten, 1866. **Holst:** Uebersicht über die Bakteriologie (*Ger. Transl.* from the Norwegian), 1891. **Hueppe:** Die Formen d. Bakterien, etc., 1886; *also*, Die Methoden der Bakterien-Forschung, 1889. **Klein:** Micro-organisms and Disease, 1886. **Koch** (Examination of Micro-Organisms): Mitth. a. d. k. Gesundheitsamte, i. 1881, p. 1; *also*, Ueb. d. bakteriol. Forschung, 1890; *also, Eng. Transl.* **Köhler:** Der Heupilz., 1881. **Kühne:** Practical Guide to the Demonstration of Bacteria in Animal Tissues (*Eng. Transl.*), 1890. **Laurent** (Reduction of Nitrates in Veget. Kingdom): Ann. de l'Inst. Pasteur, iv. 1890, p. 722. **Lichtheim** (Pathogenic Micro-Organisms): Berl. klin. Wochnschr., xix. 1882, pp. 129, 147. **Lindt** (Some New Pathogenic Organisms): Arch. f. exper. Path. u. Pharmakol., xxi. 1886, p. 269. **Lister:** Trans. Path. Soc. Lond., xxix. 1878, p. 425; *also* (Relation of Micro-Organisms to Disease), Quart. J. Mic. Sc., xxi. 1881, p. 330. **Loeffler:** Vorlesungen üb. d. geschichtliche Entwickelung d. Lehre v. d. Bakterien, 1887; *also* (Staining of Cilia), Centralbl. f. Bakteriol. u. Parasitenk., vii. 1890, p. 625. **Lutz** (Relationship between Rods and Cocci): Fortschr. d. Med., iv. 1886, p. 327. **Macé:** Traité pratique de bacteriologie, 1892. **Marey** (Movements of Microscopic Organisms): Compt. rend. Acad. d. sc., cxiv. 1892, p. 989. **Migula:** Bacteriologisches Practicum, 1892. **Moore** (Staining of Cilia): Proc. Am. Soc. Micr., xiii. 1892, p. 85. **Nägeli:** Die niederen Pilze in ihren Beziehungen z. d. Infectionskrankheiten, 1877. **Nicolle and Morax** (Coloration of Cilia): Ann. de l'Inst. Pasteur, vii. 1893, p. 554. **Ogata** (Cultures with different Gases): Centralbl. f. Bakteriol. u. Parasitenkrank., xi. 1892, p. 621; *also* (Pure Culture of Certain Protozoa), Centralbl. f. Bakteriol. u. Parasitenkrank., xiv. 1893, p. 165. **Petri and Maassen** (Apparatus for cultivating Anaerobes): Arb. a. d. k. Gesundheitsamte, viii. 1892, p. 318; *also* (Generation of Sulphuretted Hydrogen by Aerobes and of Merkaptan by the Same), *Ibid.*, viii. 1893, p. 490. **Péré** (Bacterium Coli Commune and Typhoid Bacillus): Ann. de l'Inst. Pasteur, vi. 1892, p. 512. **Recent Essays on Bacteria, etc.:** N. Syd. Soc., 1886, edited by Cheyne. **Sanderson** (Croonian Lectures on Infection): Brit. Med. Journ., 1891, ii. p. 983. **Schenk:** Grundriss der Bakteriologie, 1893; *also, Eng. Transl.*, 1893. **Schlüter** (Growths on Acid Bases): Centralbl. f. Bakteriol. u. Parasitenkrank., xi. 1892, p. 589. **van Senns** (Culture of Anaerobes): Centralbl. f. Bakteriol. u. Parasitenkrank., xii. 1892, p. 144. **Sherrington** (Escape of Bacteria with the Secretions): Journ. Path. and Bacteriol., i. 1892-93, p. 258. **Sternberg:** A Manual of Bacteriology, 1892. **Straus** (Coloration of Cilia): Compt. rend. Soc. de biol., iv. 1892, p. 542. **Stricker:** Allgem. Path. d. Infectionskrankheiten, 1886. **Trambusti** (Apparatus for cultivating Anaerobes): Centralbl. f. Bakteriol. u. Parasitenkrank., xi. 1892, p. 623. **Trambusti and Galeotti** (Structure of Bacteria): Centralbl. f. Bakteriol. u. Parasitenkrank., xi. 1892, p. 717. **Trenkmann** (Staining of Cilia): Centralbl. f. Bakteriol. u. Parasitenk., viii. 1890, p. 385. **Weichselbaum** (Ætiology and Path. Anat. of Infectious Diseases): Wien. med. Bl., viii. 1885, p. 5 *et seq.* **Welch** (Bac. Communis Coli): Med. News, Phila., lix. 1891, p. 669. **Woodhead:** Bacteria and their Products, 1891. **Woodhead and Hare:** Pathological Mycology, 1885.

CHAPTER XCVII

B. THE ANIMAL PARASITES OF MAN

1151. THESE belong chiefly to the sub-kingdoms Protozoa, Annuloida (Vermes), and Arthropoda.

PROTOZOA.

They are found in various situations, more especially in passages secreting mucus and opening externally, such as the mouth, nares, bronchi, vagina, intestine, bile-ducts, etc. Some of them inhabit the blood.

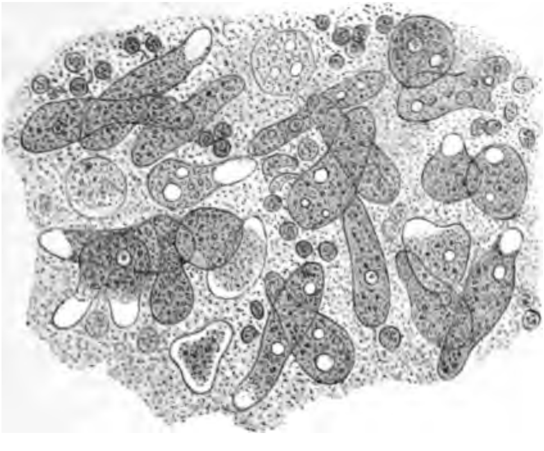


FIG. 589.—AMŒBA COLI.

The simplest form belongs to the **Rhizopoda** and genus Amœba. The only amœba which has been observed to be parasitical on Man is A. coli. It has been referred to already (p. 541) as occurring in the large intestine and dejecta of dysentery. Amœba is a common parasite of insects.

The class of **Sporozoaria** was founded by Leuckart, and comprises unicellular organisms which are usually regarded as belonging to the animal kingdom—as indeed a branch of the protozoa. According to Balbiani (No. 520, rep. by Wickham), it comprises (1) the gregarinidæ; (2) the oviform psorospermia or coccidia; (3) the sarcosporidia or tubes of Miescher; (4) the psorospermia of fish or myxosporidia; and (5) the psorospermia of the articulata or microsporidia. They all exist parasitically on animals.

The term **psorosperm** is usually applied to a coccidium which has become encapsuled. In Man the liver and other organs are rarely the seat of them. In the intestine of the rabbit **coccidium oviforme** is a common parasite. It finds its way into the bile-ducts and causes cystic dilatation of these with the formation of papilla-like ingrowths from the interior (Fig. 591). These psorosperms give rise to yellowish-coloured cheesy tumour bodies about the size of a millet seed and somewhat like tubercles in general appearance. Numerous coccidia are found in their interior. In the rabbit they form large cheesy masses. Coccidia have a remarkable power of retaining basic aniline dyes in the presence of decolorising reagents. They almost resemble tubercle bacilli in this respect. According to Delépine (No. 6, 1889, ii. p. 1393) the parasite creeps along the bile channels. Next within it there develop numbers of very large highly-refractile bodies, which rupture the enveloping capsule and penetrate into the interior of the epithelial cells of the bile-ducts. These embryo bodies then go on enlarging, and their protoplasm becomes nucleated and nucleolated. They escape subsequently from the cell which acts as their host. From some of them a long filament is produced, probably the pseudo-filaria of van Beneden.

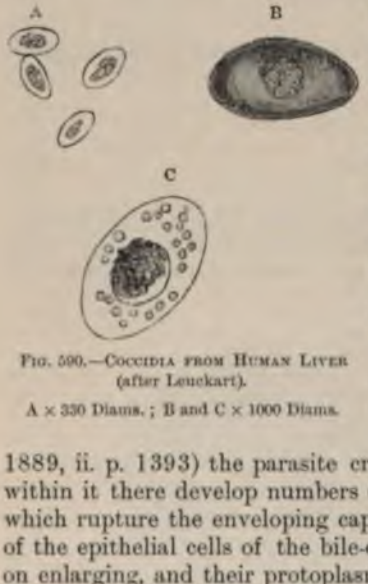


Fig. 590.—Coccidia from Human Liver (after Leuckart).

A × 330 Diams.; B and C × 1000 Diams.

Miescher's cylinders or **Rainey's capsules** are cylindrical or tube-like structures found in the heart and the other muscles of the pig. They consist of a capsule containing innumerable oval or reniform bodies not unlike the embryo coccidia just described.

Cancer Bodies.—In referring to **Paget's disease of the nipple** (p. 803) mention was made of bodies which are found in the interior of the epithelial cells of the excoriated skin, and which are generally believed to belong to this class of animal parasites. They are found in most cancerous tumours, and apparently always reside within epithelial cells. For the most part they inhabit the protoplasm of the cell, but are also to be found in the nucleus. They are distinguished from the sporozoaria of other groups by absence of movement at any period of their development, by their intra-cellular habitat, by their solitary encystment not preceded by conjugation, and by the number of spores which form in the cyst being relatively restrained (Wickham, No. 662, p. 151).

The objects in question in their youngest form appear as round or rounded bodies which are refractile, and which stain well with various reagents such as Biondi's fluid.[1] Later on, they develop a double-

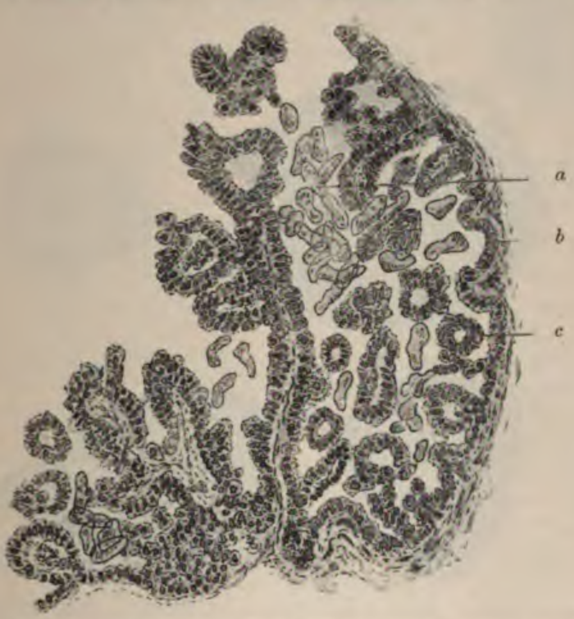


FIG. 591.—DILATED AND TRANSFORMED BILE DUCT CONTAINING COCCIDIA, FROM LIVER OF RABBIT (×300 DIAMS.)

(*a*) The coccidia; (*b*) altered wall of original bile duct; (*c*) adenoma-like ingrowths from original wall (Picro-carmine and Clarified).

---

[1] The Ehrlich-Biondi or Ehrlich-Biondi-Heidenhain Fluid (No. 169, xlii. 1888, p. 1; No. 48, v. 1888, p. 520) is somewhat troublesome to prepare. The receipt is as follows: To 100 c.c. saturated aqueous solution of Orange add with continuous agitation 20 c.c. saturated aqueous solution of Acid Fuchsin and 50 c.c. of a like solution of Methyl-green. Dilute the mixture with 60 to 100 vols. of water.

The dilute solution ought to redden if acetic acid be added to it; and if a drop be placed on blotting-paper it should form a spot bluish-green in the centre, orange at the periphery. If the orange zone is surrounded by a broader red zone the mixture contains too much Fuchsin.

The sections should be stained for six to twenty-four hours. They are afterwards washed out with alcohol, cleared with xylol, and mounted in xylol balsam.

According to Heidenhain's most recently published instructions (No. 48, ix. 1892, p.

contoured capsule with clear contents and a nucleus. The nucleus does not stain well with ordinary nuclear dyes, but stains sometimes in a differential manner with compound aniline dyes such as Biondi's fluid. A peculiar radiate arrangement of the protoplasm or contents of the body is sometimes noticed around the nucleus (Fig. 592, 2). With an aniline dye mixture such as that above mentioned, the contents sometimes stain of a different colour from the nucleus.

These bodies have never been cultivated artificially, nor have they been inoculated, and it may be added that considerable doubt is expressed by some investigators as to their being parasites at all. It has been alleged that they are merely degenerated nuclei. It cannot be said as yet that they have anything to do with the production of cancerous tumours. It is asserted that they have been detected in the epithelium of the skin after the application of a blister.

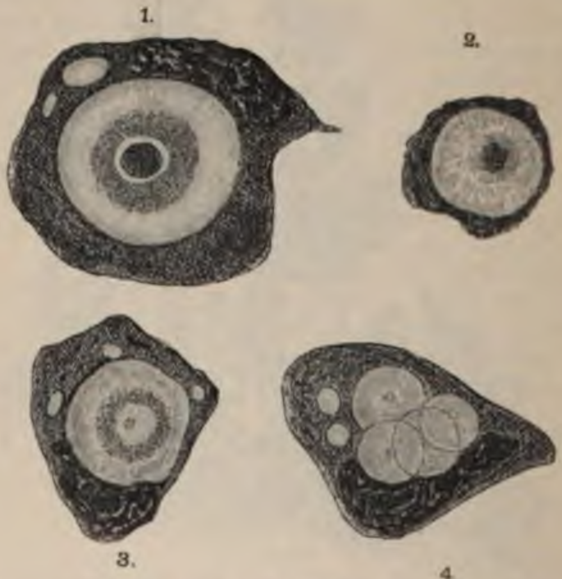


FIG. 592.—CANCER BODIES (after Ruffer and Walker).

(1) Cell from cancer of stomach containing a large parasite and two small vacuoles. The nucleus of the cell is pushed to one side (Zeiss Oc. 3, Obj. $\frac{1}{12}$; 1200 Diams.)

(2) Cell from same, showing a parasite with well-marked rays extending to the periphery. The nucleus of the cell has disappeared (Beck Oc. 3, Obj. $\frac{1}{12}$).

(3) Same, showing a parasite and three small vacuoles. The nucleus of the parasite is very small (Zeiss Oc. 3, Obj. $\frac{1}{12}$; 1200 Diams.)

(4) Same, containing four parasites (do.)

---

202), the Orange to be used should be "Orange G," the Acid Fuchsin "Rubin S," and the Methyl-green "Methyl-green OO," all to be obtained from the Actienfabrik für Anilinfabrication, Berlin.

Russell's Fuchsin Bodies.—These are peculiar round homogeneous and refractile structures described by Russell (No. 6, 1890, ii. p. 1356) as being present in cancerous tumours, sarcomata, etc., particularly in cancer tumours. They vary in size from about that of a coloured blood-corpuscle up to six, eight, or more times as large. One peculiarity about them is their affinity for fuchsin. If a section containing them be stained with fuchsin and subsequently treated with iodine green, the fuchsin colour is washed out from all parts of the section unless the bodies in question.

They were supposed to be of the nature of protozoa and to stand in a causal relationship to the cancer tumours in which they are so often found. Neither of these allegations has ever been established. They are found abundantly in myomata and other pathological new growths.

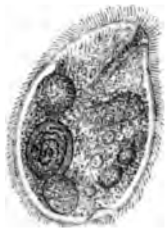


FIG. 593.—BALANTIDIUM OR PARAMÆCIUM COLI (after Malmsten; × 300 DIAMS.)

Paramæcium.—This occasionally becomes parasitical on Man. One variety, P. or Balantidium coli, is found in the intestine and dejecta. Its presence was detected originally by Malmsten. Symptoms of tenesmus and passage of blood by the bowel are associated with it (Stieda, No. 13, xxxvi. 1866, p. 285).

Cercomonas Intestinalis.—The parasite has a pear-shaped body from 8-10 μ long, obtusely rounded at the one end, and tapering to a fine extremity at the other. To the broad end a long whip-like cilium is attached. Within the body a nucleus may sometimes be detected. The parasite occurs in the dejecta in various diseases. A Cercomonas urinalis is also described in the urine.

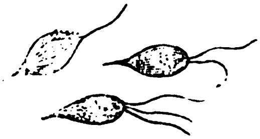


FIG. 594.—TRICHOMONAS VAGINALIS (after Kölliker; × 500 DIAMS.)

Trichomonas Vaginalis.—This has a close resemblance to the foregoing, but is provided with from one to three long cilia which are usually in active motion. The habitat is in mucous or muco-purulent discharges from the vagina.

The Parasites of Malaria.

1152. There has perhaps been no more brilliant discovery in the domain of pathology within recent times than that by Laveran (1880) of the parasites, apparently of the nature of protozoa, within the blood of those suffering from malarious fever.

From its very nature ague fever has long been supposed to be of parasitical origin, and some years ago Klebs and Tommasi Crudeli (see Bibliog.) isolated from the marshy soil round about Rome a rod from 2 to 7 μ long, sometimes elongating into threads, and which, from the fact that it determines a febrile state in rabbits, they supposed to be the parasite they were in search of. In view, however, of the more recent and apparently more reliable discovery of Laveran, this vegetable parasite is no more regarded as the active agent in malaria.

The plasmodia, as the parasites are called, belong neither to the bacteria nor the fungi proper, but are evidently a group of the lowest animal forms, namely the protozoa.

The parasite, according to Laveran (No. 624, p. 14), presents itself under the four following types: (1) spherical bodies; (2) flagella; (3) crescentic bodies; and (4) segmented bodies or bodies arranged *en rosace*.

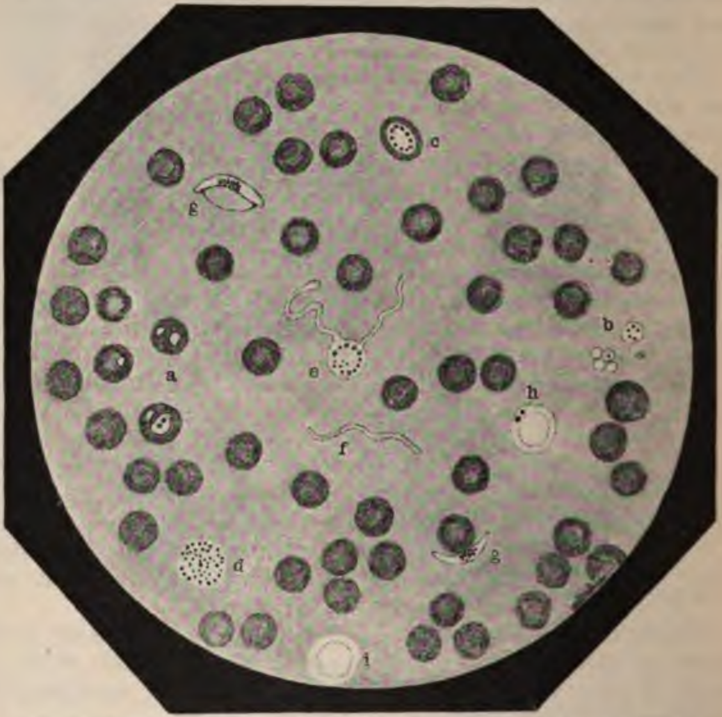


Fig. 595.—Hæmatozoa in Fresh Malarious Blood (after Laveran; × 500 Diams.)

(*a*) Group of three blood-corpuscles with spherical hæmatozoa adherent to them; (*b*) small free spherical bodies; (*c*) spherical body of medium size adherent to a blood-corpuscle; (*d*) free spherical body arrived at stage of complete development; (*e*) spherical body with two flagella; (*f*) free flagellum; (*g*, *g*) crescentic bodies; (*h*) leucocyte containing melanine; (*i*) normal leucocyte.

1. **The Spherical Bodies.**—These are the commonest form. They are composed of a hyaline substance and are of various dimensions, the smallest having a diameter of at least 1 μ, the largest a diameter equal to, or even greater than, that of a coloured corpuscle. The diameter of some of them is even double that of a coloured cor-

puscle. The smallest (Fig. 596, 1 to 4) are devoid of, or present only a few grains of pigment, and are adherent to, not embedded in, the substance of the coloured corpuscles of the blood, but as they increase in bulk the grains of pigment become augmented in number and arrange themselves often in the form of a corona (Fig. 596, 10) towards the margin of the parasite. In other instances they are aggregated irregularly in the body (Fig. 596, 5 to 8). The pigment is moved about by the amœboid contractions of the host. The parasites are either embedded in the coloured blood-corpuscles or are free in the blood plasma. Several are sometimes contained in the substance of a single corpuscle. They live evidently at the expense of the cell host, and increase so rapidly in bulk that there arrives a time when the corpuscle is entirely consumed by them.

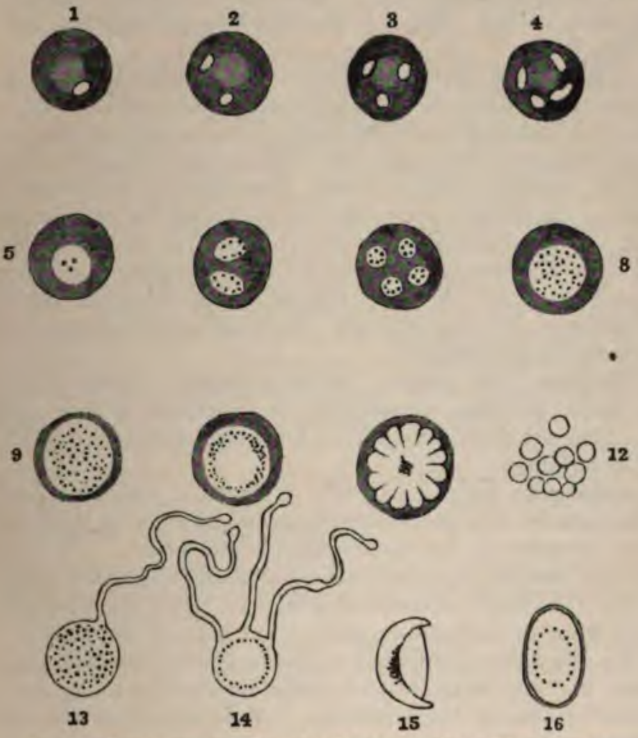


FIG. 596.—PLASMODIA FROM BLOOD OF MALARIOUS FEVER (after Laveran).

(1-4) Coloured blood-corpuscles with small spherical plasmodia devoid of pigment adherent to them; (5-8) same with spherical plasmodia containing pigment particles; (9) a corpuscle almost destroyed by the contained parasite; (10) large parasite, with pigment particles arranged in a ring at the periphery, enclosed in a blood-corpuscle; (11) a parasite showing radial segmentation; (12) the segments set free as spherical bodies; (13, 14) free spherical plasmodia with flagella; (15) free crescentic body; (16) oval-shaped body derived from one which is crescentic.

A nucleus has been described as present in some of the bodies, but Laveran considers that, if such exist, it must be difficult to see.

2. **Flagella.**—Some of these round parasites are provided with delicate flagella. They move with great rapidity, and agitate the corpuscles lying in their neighbourhood. From one to four such flagella may come off from a single parasite (Fig. 596, 13, 14; and Fig. 595, *e*). They are so transparent that, in spite of their great length, they are hardly ever visible. They often become separated from the parent (Fig. 595, *f*).

3. **Crescentic Bodies.**—These are cylindrical bodies, more or less pointed at either end and presenting a crescentic curve. Their substance is transparent and uncoloured unless at their middle, where granules of pigment are found (Fig. 595, *g*, *g*; and Fig. 596, 15). Their length is usually a little greater than that of a coloured blood-corpuscle. On their concave side a line uniting the two ends is often noticed. These crescentic elements remain free in the blood; when one of them becomes attached to a blood-corpuscle the attachment is accidental, so that if the cover-slip be lightly disturbed the body in question becomes easily detached. They are devoid of movement and are unprovided with flagella.

4. **Bodies "en rosace" or segmented.**—Such bodies are of round shape, and the segmentation is sometimes regular and "sun-like." They are found in quartan fever, sometimes in quotidian, but rarely in tertian.

According to Golgi (No. 366, x. 1891, p. 136) this form is of great importance as representing the principal mode of multiplication.

The hæmatozoon increases evidently by fission. It is seen to divide into several segments, which separate from each other (Fig. 596, 12). The fission sometimes presents a radial character (Fig. 596, 11), and when so the pigment gathers in a mass at the centre.

When the separation of the segments is completed the pigment is liberated, and may be absorbed by adjacent leucocytes (Fig. 595, *h*), or carried about free in the circulation. It is thus that the melanotic pigmentation of the liver, spleen, etc., in malaria, is to be accounted for. The pigment is a product of the hæmoglobin of the hæmocyte, and is elaborated by the parasite adherent to it.

Relative Frequency of the above.—Of 432 cases in which Laveran made out the presence of the parasites in persons suffering from malarious fever in Algeria the following was noted :—

Spherical bodies alone	266 times
Crescentic bodies alone	43 ,,
Spherical and crescentic bodies	31 ,,
Spherical and flagellated bodies	59 ,,
Spherical, crescentic, and flagellated bodies . . .	33 ,,

The spherical bodies alone or associated with others have thus been observed by him 389 times out of 432; the crescentic bodies alone or associated with others, 107 times; those which were flagellated were associated always with those which were spherical, and in 92 of the 432 observed cases.

Relationship of one Form to the Other.—This seems somewhat doubtful as yet. Laveran, however, inclines to the idea that they are successive stages of the same parasite. The interpretation of the significance of the crescentic bodies still remains obscure.

Effect on the Blood.—Dionisi (No. 49, 1891, i. p. 287) says that where the plasmodia are abundant the loss in coloured blood-corpuscles may amount to from 200,000 to 1,000,000 per cu. mm. In the intervals of the attacks a recuperation takes place. In early attacks the destruction is greater than in those which come on later.

Relationship to the Fever.—The parasites are most numerous and most characteristic at the time of access of the fever. It has been supposed, more especially by Italian observers, that the different forms of fever (quotidian, tertian, quartan) are the result of different species of parasite, and that the course of the fever corresponds to the extent of the life history of the parasite. Golgi found, for instance, that in *quartan fever* the life history of the parasite, from the time of invasion of the blood-corpuscle up to complete division of the ripe plasmodium, occupied three days; while in the case of *tertian fever* the same cycle of events was accomplished in two days. Laveran, however, has doubts as to any such relationship having been conclusively demonstrated. It is generally admitted that the crescentic variety is more common where a relapse has occurred, or where the malarious cachexia has been established.

Parenski and Blatteis (No. 49, 1892, ii. Ab. 1, p. 19) also believe that the tertian and quartan varieties are due to separate parasites; the quotidian, they hold, is the result of a mixed infection.

Golgi, Canalis, and Celli have described three distinct kinds of plasmodium. Laveran regards them all as merely stages in the life history of the same parasite. The species seems to differ according to south or north latitude.

The following are described by Celli and Marchiafava (No. 625, p. 189) as the characteristic forms in the various types of malarious fever. They are best seen in blood obtained by puncturing an internal organ during life. In the **quotidian type**, which is the most severe, small shining bodies having active amœboid movements are found within the blood-corpuscles. Their number varies, but they are found in all pernicious types of the disease. They are sometimes enclosed in leucocytes, or in endothelial cells, in which also black pigment is to be seen. Flagellated and half-moon-like shapes may also be noticed in the corpuscles, but, with Laveran, the authors regard all these as merely phases in the life history of a single parasite. In the **tertian type** small amœboid bodies are found which, as they grow, become filled rapidly with pigment. They manifest lively amœboid movements. The black granules, moreover, are finer than in the quartan. The authors describe a special parasite in the **quartan variety**, of which they give a drawing in the above-referred-to publication.

Attempts to Cultivate and Transmit.—The artificial cultivation of the plasmodia as yet has proved unsuccessful, even when the culture basis has been pure blood. Efforts aimed at conveying the disease to the lower animals have also failed, although in their blood organisms evidently closely related to those of malaria are to be found in malarious districts.

The interhuman transmission of the disease, however, has been accomplished by injecting a small quantity of malarious blood containing the organism into the venous system of a fresh subject.

Method of examining the Blood.—The blood is best examined fresh at an ordinary temperature. The use of the warm stage is unnecessary. It should be examined from time to time and at different times, as it may happen, more particularly if the subject of observation has been taking quinine, that the plasmodia have temporarily disappeared.

Cover-glass preparations can be kept if they are simply dried with heat. Perosmic acid as a fixing agent is not required. The blood ought to be taken from the finger after washing the skin with soap and water and alcohol. It is received between two cover glasses so as to spread it out in a sufficiently thin film. The cover glasses are separated and dried gently over a flame. They may afterwards be rolled up in paper and labelled.

The blood can also be examined very well in its dried state. Canada balsam renders it too transparent. It may be stained to advantage with methylene blue and eosin. The methylene blue stains the parasite, the eosin the blood-corpuscles.

Parenski and Blatteis (No. 49, 1892, ii. Ab. 1, p. 19) examine the movements of the plasmodia on the warm stage in blood diluted with serum stained with methylene blue. The plasmodia take on the blue colour readily, and retain their movements for long. For staining permanent cover-glass preparations they recommend—

℞

Sol. aquos. satur. methyleni coerulei . . .	100
Eosini aqua solub.	0·50
Alcoholis absol.	15·0

The blood-corpuscles stain red, the nuclei of the colourless corpuscles deep blue, and the plasmodia pale blue.

Action of Remedies.—According to the same authorities, quinine is destructive only to the mature forms, not to those intermediate. It ought, therefore, to be given during the attack, not in the intervals, as it is at the time of the attack that the plasmodia exist in their fully-developed condition. Methylene blue given internally causes the plasmodia to disappear from the blood without any untoward result. Antipyrin and antifebrin are both active, while salicylic preparations are without effect.

General Conclusions.—Summing up the various arguments in favour of the parasites in question being the cause of malarious fever, they are the following :—

(1) Hæmatozoa having identical characters have been found in malarious subjects in all countries.

(2) These hæmatozoa have never been met with in persons who were not affected with malaria.

(3) The development of the hæmatozoa is intimately related to the production of melanæmia, which is so peculiarly characteristic of malaria.

(4) The salts of quinine cause the disappearance of the organism at the same time as they cure the fever.

(5) The interhuman transmission of the disease through infected blood.

Literature on Malaria.—**Binz** (Amœba): Terap. mod., Padova, v. 1891, p. 561; *also* (Action of Quinine on Malaria Amœba), Berl. klin. Wochnschr., xxviii. 1891, p. 1045. **Bonebakker:** Het Plasmodium malariæ, 1891. **Brush** (Blood in): N. Y. Med. Rec., xli. 1892, p. 66. **Catrin:** Le paludisme chronique, 1893. **Ceci:** Arch. f. exper. Path. u. Pharmakol., xv. 1882, p. 153; *Ibid.*, xvi. 1882, p. 1. **Councilman:** Trans. Am. assoc. of am. physicians, 1886, p. 89; Med. News, i. 1887, p. 59. **Councilman and Abbot:** Am. Journ. Med. Sc., 1885, p. 416. **Danilewski:** Ann. de l'Inst. Pasteur, v. 1891, p. 758. **Evans:** Proc. Roy. Soc. Lond., xlix. 1891, p. 199. **Glogner** (Examination of Blood in the Tropics): Arch. f. path. Anat., cxxxii. 1893, p. 314. **Golgi** (Amœba of Quartan Fever): Ztschr. f. Hyg., x. 1891, p. 136. **Hehir:** Microscopical Observations on Hæmatozoön of M., 1891. **Kaufmann** (Plasmodia): Fortschr. d. Med., x. 1892, p. 1000. **Klebs and Tommasi-Crudeli:** Arch. f. exper. Path. u. Pharm., xi. 1879, pp. 122, 311; *also*, Reale Academia dei Lincei, Rome, 1878-79, *Eng. Transl.*, N. Syd. Soc., 1888; *also*, Practitioner, xxiii. 1879, p. 107. **Laveran:** Nature parasitaire des accidents de l'impaludisme, 1881; *also*, Compt. rend. Soc. de biol., iii. 1891, p. 127; *also*, Du paludisme et de son hématozoaire, 1891; *also*, Compt. rend. Soc. de biol., iv. 1892, pt. ii. p. 327; *Ibid.*, v. 1893, p. 312; *also*, Tr. VII. Internat. Cong. Hyg. and Demog., 1892, ii. p. 10. **Marchand:** Arch. f. path. Anat., lxxxviii. 1882, p. 104. **Marchiafava and Celli:** Fortschr. d. med., iii. 1885, pp. 339, 787; *also*, Arch. per le sc. med., xiv. 1890, p. 117. **Marchiafava and Cuboni:** Arch. f. exper. Path. u. Pharm., xiii. 1881, p. 265. **Nepveu** (Flagellated Bodies included in White Cells): Compt. rend. Soc. de biol., iii. 1891, p. 699; *also* (Alterations in Capillaries of Liver), *Ibid.*, iv. 1892, p. 233 *et seq.* **Pfeiffer:** Fortschr. d. Med., viii. 1890, p. 939. **Richard:** Revue scientifique, 1883, p. 113. **Ruffer:** Brit. Med. Journ., 1893, ii. p. 825. **Sacharoff:** Amœbæ malariæ (ten coloured plates), 1892. **Thayer** (Treatment with Methylene Blue): Bull. Johns Hopkins Hosp., iii. 1892, p. 13. **Vincent** (Hæmatozoön): Compt. rend. Soc. de biol., iv. 1892, p. 255.

Protozoa of the Blood in the Lower Animals.

In India and in other countries with a warm climate the blood of the lower animals, and especially the rat, often contains minute flagellated protozoa. The author remembers seeing these in the blood of rats in this country, and the explanation of their presence seemed to have been that the rats had gnawed straw packing which had come from India and lay in the cellar where they were caught. Lewis has drawn special attention to these parasites.

Literature on Blood Parasites.—**Cobbold:** Brit. M. Journ., 1876, i. p. 780. **Danilewski:** Arch. slaves de biol., i. 1886, p. 85. **Leisering** (Hæmatozoa of Domestic Mammals): Arch. f. path. Anat., xxxiii. 1865, p. 111. **Lewis:** On a Hæmatozoon inhabiting Human Blood; its Relation to Chyluria and other Diseases, 1872; *also*, Pathological Significance of Nematode Hæmatozoa, Rep. San. Comm. India, 1874, p. iii. **Gaule** (Würmchen): Arch. f. Anat. u. Physiol., Phys. Abth., 1880, p. 57. **Gluge** (Entozoon in Blood of Frog): Arch. f. Anat. Phys., u. Wissensch. Med., 1842, p. 148. **Manson** (Chinese Hæmatozoa): Med. Times and Gaz., 1877, ii. pp. 513, 538, 563, 589; *also*, The Filaria Sanguinis Hominis, etc., 1883. **Osler**: Proc. Roy. Soc., xxii. 1873-74, p. 391. **Platner**: Arch. f. Mik. Anat., xxvi. 1886.

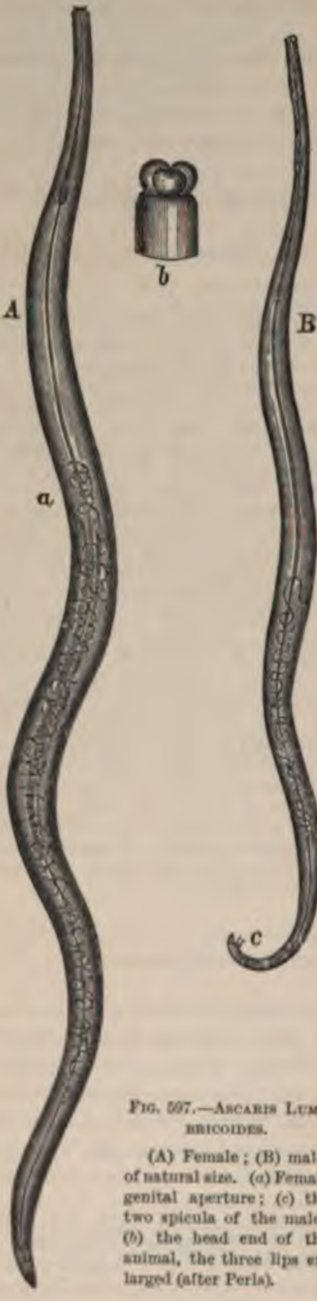


FIG. 597.—ASCARIS LUMBRICOIDES.

(A) Female; (B) male, of natural size. (*a*) Female genital aperture; (*c*) the two spicula of the male; (*b*) the head end of the animal, the three lips enlarged (after Perls).

VERMES.

THE ROUND WORMS OR NEMATODA.

Ascaris Lumbricoides.

1153. A round cylindrical worm with both ends pointed, the posterior more so than the anterior. The mouth is at the anterior end, and the alimentary canal runs through the entire length of the body. It has a brownish yellow or reddish tint. The skin is hard and is marked by delicate transverse striæ. Next to Eustrongylus gigas it is the largest round parasite of Man.

The sexes are separate. The female is the larger of the two, and measures from 10 to 16 inches in length and a quarter of an inch in thickness. The male is from 4 to 6 inches long and correspondingly thinner than the female. The genital opening in the female lies on the ventral aspect close behind the anterior third of the body. The genital apparatus, it is said, can hold something like 60,000,000 ova.

The posterior end of the male is slightly curved. There is a penis projecting from the cloaca, together with two slender chitinous hooks, which probably serve the purpose of affixing the male during copulation.

The ova are thrown off in immense numbers in the fæces. The development of the embryo takes places outside the body, in water or in moist earth. The ova can be frozen or retained for long in the dried state without suffering injury.

The habitat of the parasite is chiefly the small intestine, and mostly in children. Ascarides may excite a catarrh of the intestine, or give rise to certain nervous reflex phenomena.

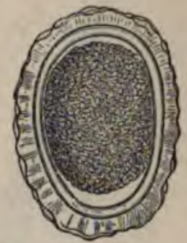


FIG. 598.—OVUM OF ASCARIS LUMBRICOIDES, WITH ALBUMINOUS PRECIPITATE AROUND IT (after Heller; × 350 DIAMS.)

Ascaris Mystax.

This is a small round worm which lives chiefly in the intestine of the cat. It has occasionally been found parasitic in Man.

Oxyuris Vermicularis (Thread-Worm).

A very common small round worm which inhabits chiefly the large intestine. The female, which is about 10 mm. ($\frac{1}{3}$ - $\frac{2}{5}$ of an inch) long, somewhat resembles a small ascaris lumbricoides in the fact that the hind end is sharply tapering. That of the male, however, is blunter. The male is only about 4 mm. in length.

Trichocephalus Dispar (Whip-Worm).

The anterior two-thirds of the body is peculiarly slender as compared with the posterior, hence the parasite has some resemblance to a whip. The male and female are from 4-5 ctm. ($1\frac{1}{2}$-2 in.) long. From the posterior rounded end of the male a penis and spiculum protrude; the genital opening of the female lies at the anterior end of the thick part. The ova are from $\frac{1}{480}$ to $\frac{1}{440}$ of an inch in their longest measurement. They develop very slowly, and only outside of the body. The habitat is the caput cæcum. The parasite is sometimes extruded in great masses.

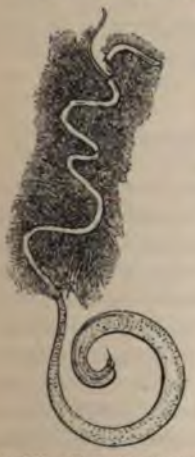


FIG. 599.—TRICHOCEPHALUS DISPAR.

Anchylostoma Duodenale (*Strongylus or Dochmius Duodenalis*).

A round parasite measuring, the male about $\frac{1}{3}$ of an inch, the female a little more. It inhabits the upper part of the small intestine, and its presence is fraught with great danger, owing to its nourishing itself by sucking the blood from the intestinal mucous membrane, to which it is usually firmly attached. A considerable quantity of blood is also lost by oozing from the punctures. Some of the most severe forms of anæmia are due to its presence. On each side of the chitinous-lined mouth are a couple of hooklets by which it effects its attachment. The ova are about 50 μ in length. They gain entrance to the body chiefly through contaminated water. It is common in North Italy, Brazil, Egypt, etc.

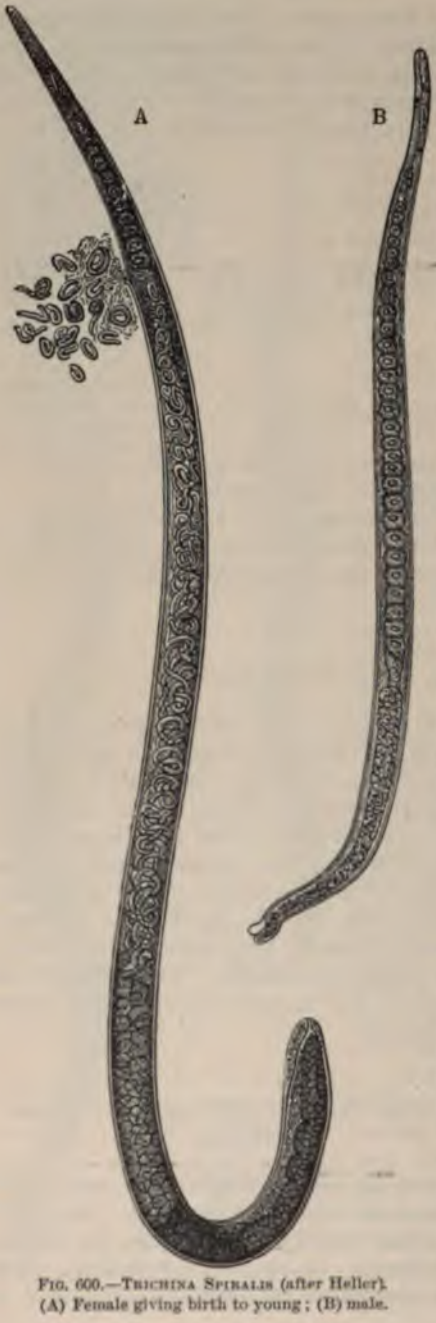


FIG. 600.—TRICHINA SPIRALIS (after Heller). (A) Female giving birth to young; (B) male.

Eustrongylus Gigas.

The largest of all the intestinal round worms, the female measuring sometimes 1 mètre in length and 12 mm. in thickness, the male about ⅓ mètre in length. It is found in several of the lower animals, but is very rare in Man.

Trichina Spiralis.

A small round worm living parasitically, in its mature state, in the intestine of many warm-blooded animals and in that of Man, and in the muscles of the same in its immature state. It gives rise to a very distressing and sometimes fatal disease, characterised by loss of appetite, prostration, emaciation, œdema of the face and extremities, and the most excruciating pains in the muscles. When its presence is unsuspected the symptoms are generally put down to rheumatism. The fatal termination is sometimes brought about by the occurrence of pneumonia.

The embryo form was discovered in the year 1835 by Sir James Paget, while a student, in the muscles of a dissecting-room subject. It was afterwards described by Owen. Its relationship to the adult intestinal worm was made out twenty years afterwards by Leuckart.

The sexually mature parasite inhabits the intestine of several warm-blooded animals and sometimes that of Man. The duration of its life is from four to five weeks. The parasite, as it is found in the muscles, is in an immature state, and requires to be transferred to the intestine of a second host before it can reach full development.

In the sexually mature condition it is only from $\frac{1}{18}$ to $\frac{1}{8}$ in. long. The body is rounded and filiform, and is usually slightly bent upon itself. It is rather thicker at the posterior than at the anterior end. The head end is narrow, finely pointed, and unarmed, and possesses a simple central minute oral aperture. The male has a bilobed appendage posteriorly to its cloacal or anal aperture, and between these is a V-shaped penis. The muscular cloaca is protruded during copulation. The female is rather stouter than the male. The genital aperture lies far forwards, about the posterior end of the first fifth of the axis. Reproduction is viviparous.

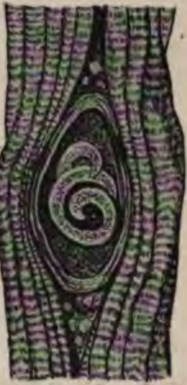


FIG. 601.—TRICHINA SPIRALIS; EMBRYO EMBEDDED IN MUSCLE (after Leuckart).

The embryos, as just stated, come to inhabit the muscles. The flat muscles, such as those of the abdominal wall and of the front of the neck, contain most of them. So numerous may they be that the muscle may appear to the naked eye as if dusted over with pepper. *Examined microscopically*, the little gray points are seen to be made up of a fibrous nodule in which are contained the embryo trichinæ. They are minute round worms coiled up two and a half times. In due course the encapsuling fibrous tissue undergoes calcification and the parasite dies and disappears, so that in cases of old standing the trichina may not be found; nothing remains but a little calcified fibrous-tumour-like body.

Soon after the intrusion of the parasite the surrounding muscular fibre loses its original structure. The fibrillæ degenerate into a finely granular substance and the sarcolemma thickens. The spot inhabited by the trichina is converted into a spindle-shaped widening, which, by consolidation of surrounding parts, becomes transformed into a cyst-like cavity.

Life History.—This is as follows: The embryos are introduced into the intestine of Man or other warm-blooded animal through eating usually infected pork. On the second day after being introduced they become sexually mature. The ova are developed into minute filaria-like embryos within the uterus of the mother, and in this condition are extruded from the genital aperture. They are born from the sixth day onwards after the trichina has taken up its residence in the intestine. The number of young in each mother is from 10,000 to 15,000.

The liberated embryos soon begin to migrate. They penetrate the intestinal wall and pass through the abdominal cavity into the intermuscular septa of the surrounding and distant muscles (Leuckart). Their number decreases from the abdomen outwards; they are more numerous on the anterior than on the posterior aspect of the body. The embryos pierce into the substance of the separate muscular bundles, and after fourteen days acquire the characters of the ordinary muscle trichinæ (Leuckart).

If now such flesh be eaten in an uncooked state by a second warm-blooded host the embryos are liberated in the stomach and again arrive at maturity in the intestine. The embryo in the case of Man is usually derived from the pig. The pig, it is said, is infected chiefly by devouring the body of the rat. Trichinosis is a common disease of the rat.

Eight per cent of American swine slaughtered are said to contain trichinæ (Belfield and Atwood). Something like 13,000 parasites may be contained in a cubic inch of muscle taken from a hog.

Some estimates have been made by Leuckart, Thudichum, Cobbold, and others as to the number of embryos which may be contained in the body of a single person. It has been calculated that in a human subject examined by Thudichum there were 40,000,000, and in another examined by Cobbold as many as 100,000,000.

In an outbreak of trichinosis which occurred in England Cobbold calculated that the flesh of a hog contained something like 80,000 to the ounce. The consumpt of a pound of such flesh would be capable of producing in the human body as many as 400,000,000 of a progeny.

The embryos are by no means destroyed in all cases by ordinary methods of roasting, cooking, pickling, or smoking. The best safeguard is to have the flesh of slaughtered animals carefully examined by competent authorities before being consumed.

Filaria Sanguinis Hominis.

For what we know of this parasite we are chiefly indebted to Lewis in India, Manson in China, and Bancroft in Australia. A very few cases have from time to time been noticed in this country. The first was described by Gabb. It appears to be indigenous only within the tropics.

Embryo Stage.—The parasite is best known in this form. It takes the shape of a minute round worm $\frac{1}{75}$ to $\frac{1}{50}$ inch long by $\frac{1}{3500}$ inch broad, which is parasitical upon the blood. Its breadth is thus very much the same as that of a coloured blood-corpuscle. It is somewhat thicker at the one end than at the other. It is enclosed in a delicate sac which is rather longer than the embryo itself. Its movements, as seen in fresh blood, are particularly lively and snake-like in character.

It is absent from the blood during the day unless quite exceptionally, and reappears by six o'clock at night. By twelve o'clock it is so abundant that a hundred may be counted in a single droplet of blood. As morning arrives they diminish in numbers, and by eight or nine o'clock again disappear. It is not known what comes of them in the intervals in which they are absent.

Mature Parasite.—The mature parasite was discovered by Bancroft, one in a lymphatic abscess of the arm, and four others in a hydrocele of the cord. It is about the thickness of a human hair and from 3 to 4 inches long. It is viviparous, and emits the embryo filariæ in immense numbers from the genital aperture about the centre of the body. The male and female are separate.

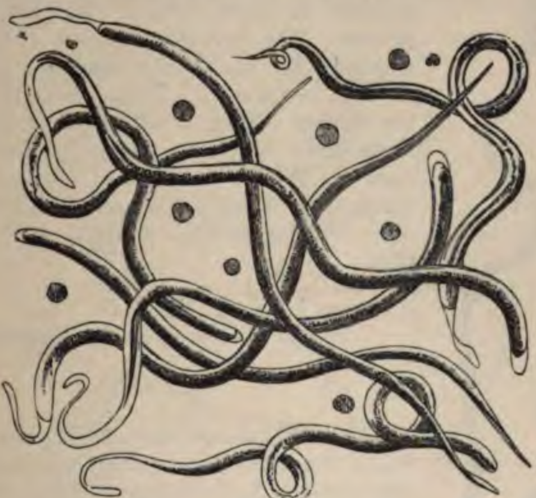


FIG. 602.—FILARIA SANGUINIS HOMINIS (after Lewis).

Life History.—It is alleged by Manson that the embryo filariæ gain entrance to the human body through the agency of the mosquito. In the stomachs of mosquitos which had bitten a filarious subject numerous filariæ were found by him in a living state several days after they had been intussuscepted. The mosquito deposits its eggs on the surface of water and subsequently dies, and it is supposed that the filariæ get into drinking water from the dead body of the mosquito and thence are transferred to the fresh host.

Diseases induced by it.—They are said to be present in the blood of 10 per cent of natives in India where the disease is endemic, but many of these do not suffer in health. The parasite, in its embryonic state, may apparently escape from the kidney and induce

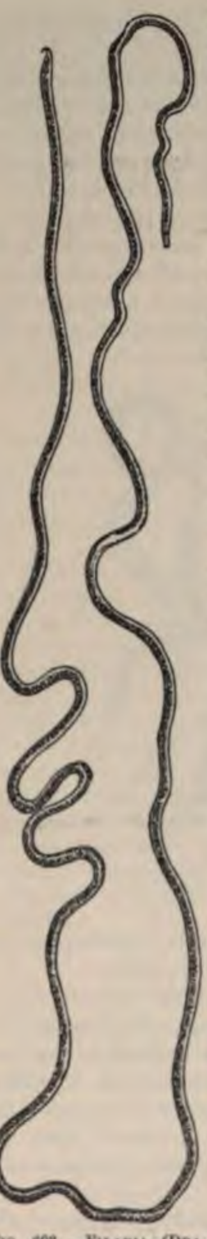


FIG. 603.—FILARIA (DRACUNCULUS) MEDINENSIS (life size; after Leuckart).

hæmaturia. Much more frequently it accompanies Chyluria and Lymph Scrotum (see description under these headings).

Guinea-Worm (Dracunculus Medinensis).

A nematode from 1 to 6 feet long and about $\frac{1}{10}$ inch in thickness. The body is uniformly cylindrical. The male dracunculus is unknown. The female lies in the subcutaneous tissues of different parts of the body, usually the leg or some other part which touches water, as the shoulder in water-carriers. The parasite is viviparous. The embryo parasites (Fig. 604) are emitted from the genital aperture and are cast off into the water. They attach themselves to the skin of the leg or other part and manage to make their way into the subcutaneous areolar tissue. When the female is distended with embryos it comes to the surface and throws them off. In doing so it gives rise to great local irritation.

SUCTORIAL WORMS OR TREMATODA.

Flukes.[1]

1154. These are very rare in the case of Man, but in the herbivora are common parasites of the bile-ducts. According to Cobbold, the common fluke is the Fasciola hepatica; it is sometimes, but wrongly, said to be the Distoma hepaticum.

They are small lanceolate, flounder- or sole-fish-like bodies, about $\frac{3}{4}$ inch long and $\frac{1}{2}$ inch broad. They possess a distinct dorsal and ventral surface and a so-called head and neck. They have two suckers, one near the mouth, the other on the ventral aspect of the body. The colour is dull brown, exactly like that of a sole-fish. Their special habitat is the gall bladder and bile-ducts. They give rise in sheep to the disease known as **rot**, a disease characterised by dilatation of the bile-ducts containing the flukes, by thickening of their walls, and by the deposition of cirrhotic fibrous tissue around them. The obstruction caused by the cirrhotic tissue to the passage of the portal blood through the organ induces more or less abdominal dropsy.

---

[1] The term "fluke" is of Saxon origin, and is applied to a flat object such as a flounder, the halves of the tail of cetaceans, or the blade of an anchor.

Bilharzia Hæmatobia (Distoma Hæmatobium).

The Bilharzia is the cause of a very protracted and often fatal form of hæmaturia. Its reproductive organs are in separate individuals. The female is from 16 to 19 mm. long and almost cylindrical in form. The male is slightly shorter—from 12 to 14 mm. long. The body is flattened and posteriorly is bent inwards so as to constitute a groove or channel, the *gynæcophoric canal,* into which the female is received (Fig. 606). The female is thus the longer and the more slender of the two. The male has a horse-leech-like aspect. The mature parasite resides in the blood-vessels, more particularly those of the urinary bladder.

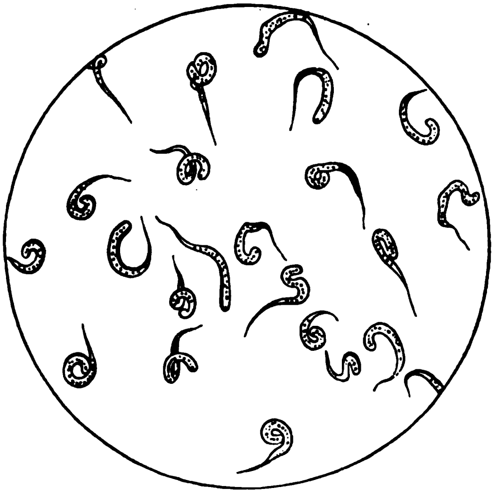


FIG. 604.—EMBRYO DRACUNCULI (after Cobbold).

The recognition of the ova is an important point, as they are shed in the urine, and the diagnosis of the disease in great measure depends on their detection. They are elongated oval bodies ·12 mm. long, sharply acuminated at one extremity (Fig. 608, *a*), and often containing black pigment. They are found adhering to the free surface of the bladder (Fig. 607) and, it may be, distributed by the blood to nearly every organ and tissue of the body. They may induce a fungoid condition of the wall of the bladder (Eve, No. 192, xxxix. 1887-88,

p. 184). Sometimes they are found on the mucous membrane of the intestine.

The embryo (Fig. 608, *c*) is a minute ciliated animalcule, and its hatching from the ovum can often be witnessed in the urine.

The parasite gains entrance, it is said, through the drinking water, and (Cobbold) through becoming parasitic on certain of the gasteropod mollusca. It gives rise to diarrhœa, hæmaturia, Egyptian chlorosis, colicky pains, and great prostration. The disease induced by it is chiefly confined to Egypt and the Cape.

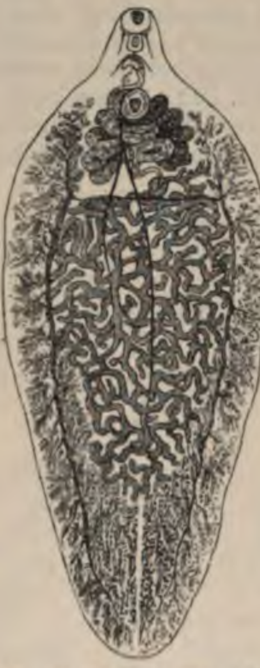


Fig. 605.—The Common Fluke (Distoma Hepaticum), showing Suckers and Male and Female Sexual Organs; about three times Natural Size (after Leuckart).

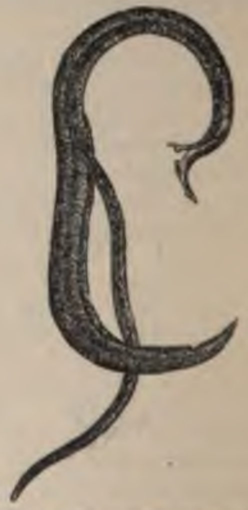


Fig. 606.—Distoma (Bilharzia) Hæmatobium, Male and Female, the Latter in the Canalis Gynæcophorus of the Former (after Leuckart).

Flat Worms or Cestoda.

1155. The flat or tape worms are among the commonest of intestinal parasites in warm-blooded animals. They can hardly be regarded as single creatures, but rather as ribbon-like colonies of many individuals jointed together. The segments are known as proglottides, and when fully grown may for some time lead a separate existence.

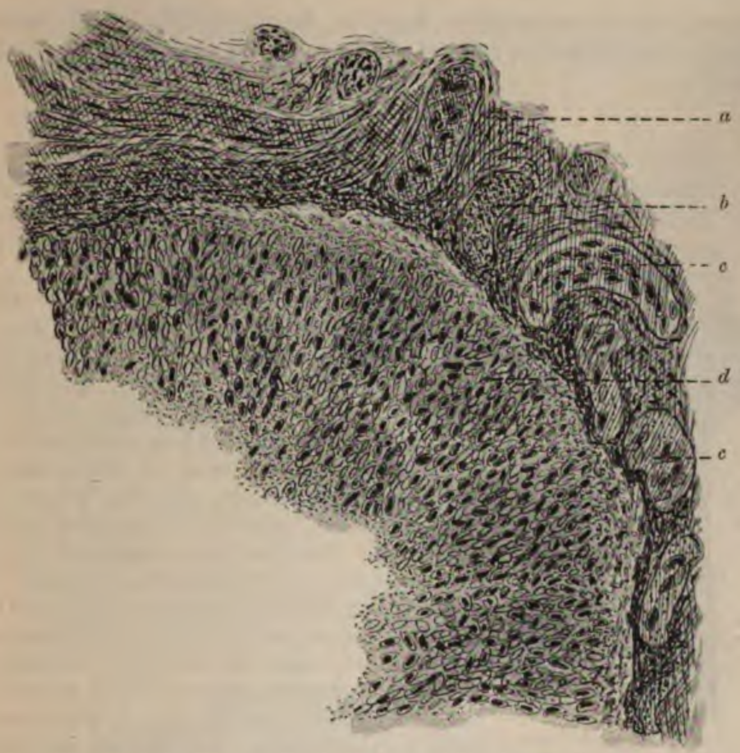


FIG. 607.—OVA OF DISTOMA HÆMATOBIUM ON WALL OF BLADDER (×50 DIAMS.)

(*a*) Muscular coat of bladder; (*b*) congested blood-vessel in same; (*c*, *c*) blood-vessels containing ova; (*d*) thick deposit of ova on surface of bladder. Most of the ova contained black pigment. They lay upon the sloughy remains of the mucous membrane, and were embedded in a granular (albuminous) substance.

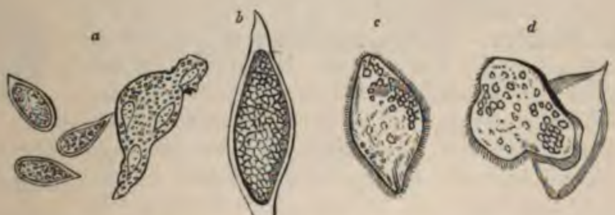


FIG. 608.—EGGS AND EMBRYOS OF DISTOMA HÆMATOBIUM OR BILHARZIA HÆMATOBIA (after Harley).

(*a*) Three ova (50 Diams.) and a portion of mucous membrane with eggs attached (×25 Diams.); (*b*) egg with segmented yolk; (*c*) free embryo; (*d*) ruptured egg with embryo escaping (×150 Diams.)

Should the head be expelled, however, the proglottides all die before long. The distinctive point of diagnosis lies in the characters of the head.

Tænia Solium.

This is the tapeworm derived from eating infected pork. It has its habitat in the small intestine. It is a long soft white jointed organism, which when alive elongates and contracts with facility.

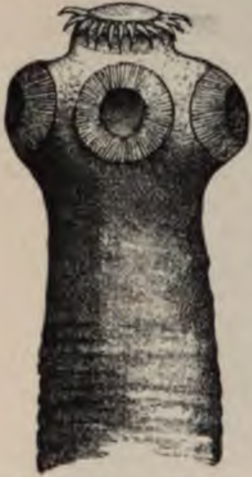


Fig. 609.—Head of Tænia Solium (after Leuckart).

The head is rarely met with on account of its being seldom evacuated. In front, there is a well-marked rostellum, and at the base of this a fringe of hooklets. The hooklets differ in size, alternately large and small. The head is provided with four round suckers. It also displays a number of dark, almost black, pigment granules, and some calcareous discs, which are particularly abundant at the base of the rostellum and neighbourhood of the hooklets. A water-vascular system, as in the other cestoda, runs down each side of the body and across the joints. The tubes are double in the region of the head. Each segment or proglottis is provided with complete male and female sexual organs, the animal being hermaphrodite. In each there is a penis and seminal vesicles, with ovary, branched uterus, and vaginal canal.

Nourishment is carried on by imbibition of the contents of the intestine.

The ova are passed in great numbers in the fæces, and give them a sand-like aspect. The ova are globular, and contain a pretty well advanced embryo at the time they are ejected. The ovicapsule is radially striated.

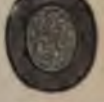


Fig. 610.—Ovum of Tænia Solium (after Heller; × about 350 Diams.)

Life History.—Immense numbers of ova escape with the fæcal matter and get into all manner of situations. They are swallowed by a second host (pig, ox, fish). They cannot develop in the original host, even although fertilised, but when taken into the stomach of the second host, the ovicapsule is dissolved by the secretion of the organ and the embryo is set free. It is provided with six siliceous hooks, and hence is known as the **six-hooked embryo** or **proscolex.** By means of these hooks it attaches itself to the wall of the stomach, and bores through its coats into a neighbouring tissue or, it may be, into a blood-vessel, by whose instrumentality it is conveyed into distant organs.

Once located in its ultimate destination, the body of the embryo becomes distended into a little cyst, while the hooklets fall off. The term **cysticercus cellulosæ** is often applied to this cyst-like stage of development, and when the cysts are scattered abundantly through the animal, the term **measly pork** or **measly beef** is applied to the flesh.

Soon a little wart-like bud shows itself on the interior of the cyst, which enlarges and becomes converted into the future head of the mature parasite. This immature head or **scolex** is further enveloped in a membrane known as **receptaculum scolicis.** The scolices are provided with hooklets, suckers, rostellum, and calcareous particles, just as in the mature animal.

If the scolex reaches the stomach of a suitable third host, such as Man, the cyst-wall is dissolved and the scolex set free, and from it is developed the chain of proglottides. The mature worm is known as the **strobila.**

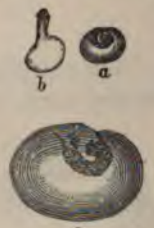


FIG. 611.—CYSTICERCUS CELLULOSÆ OF NATURAL SIZE.

(*a* and *b*) Young examples with head retracted and protruded respectively; (*c*) older example with retracted head (after Perls).

Three hosts are thus required for its development.

From **Host No. 1** the ova are thrown off.

Host No. 2 swallows the ova and liberates the proscolex or six-hooked embryo. It is transformed into the cysticercus, and within this the scolex is developed.

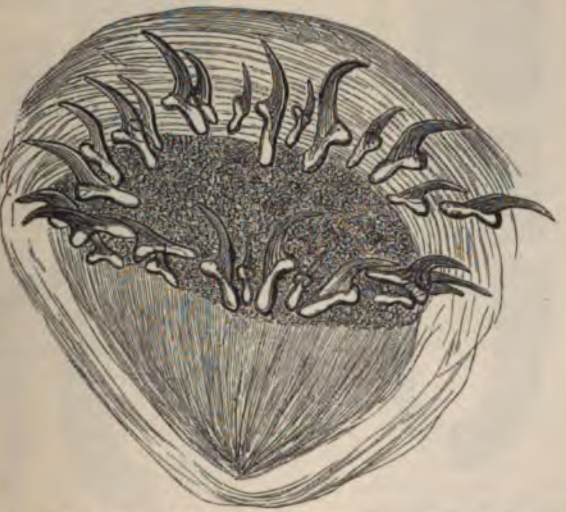


FIG. 612.—CIRCLE OF HOOKLETS OF A SCOLEX IN THE CYSTICERCUS CELLULOSÆ (after Perls; × about 110 DIAMS.)

Host No. 3 devours the scolex which throws out fresh proglottides, and thus becomes converted into the strobila or mature parasite.

Tænia Mediocanellata or Saginata.

Whereas the T. solium becomes parasitical on Man through eating infected pork, this is derived from contaminated beef. It is sometimes known as the "unarmed tænia,' from the fact of the head being unprovided with hooklets. It is also devoid of a rostellum, but is provided with four large round suckers.

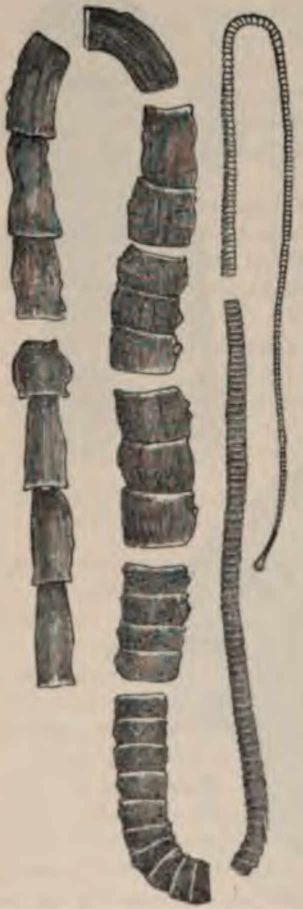


FIG. 613.—TÆNIA MEDIOCANELLATA OR SAGINATA—NATURAL SIZE (after Leuckart).

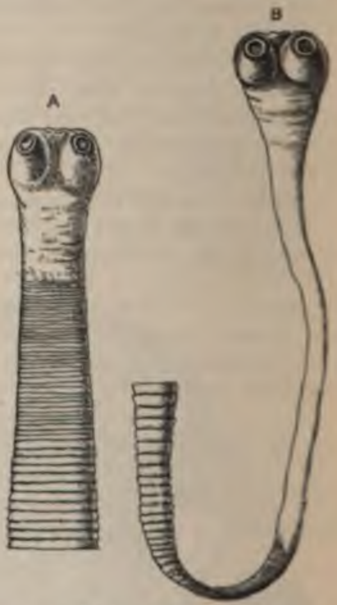


FIG. 614.—HEAD OF TÆNIA MEDIOCANELLATA OR SAGINATA (after Leuckart).

(A) Retracted and (B) extended state.

The segments as a rule are a little larger and broader than those of T. solium, but are not perfectly distinctive on that account.

Bothriocephalus Latus.

It is not common in Great Britain, but is indigenous in Ireland and in Germany. It may attain a length of 25 feet, and the segments are nearly an inch in breadth. The head is bluntly pointed at the tip, and instead of the four round suckers of the other two

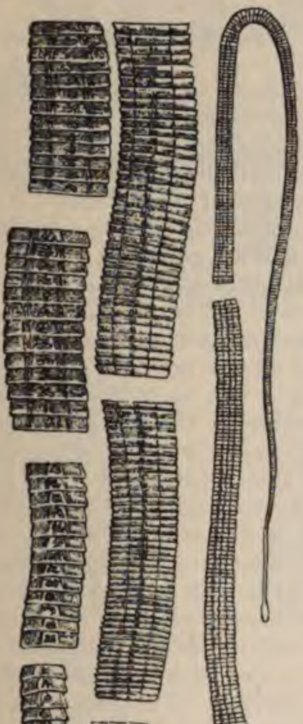


FIG. 615.—BOTHRIOCEPHALUS LATUS—NATURAL SIZE (after Leuckart).

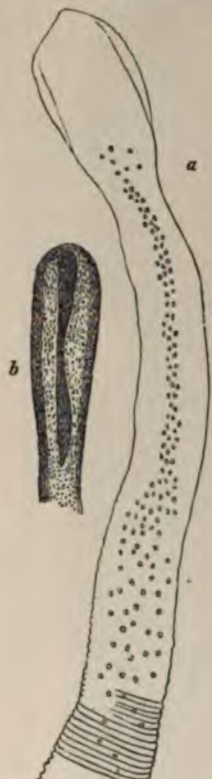


FIG. 616.—HEAD OF BOTHRIOCEPHALUS LATUS CONSIDERABLY ENLARGED (after Knoch).

(*a*) Front view, showing the neck and immature segments; (*b*) lateral view, displaying one of the bothria.

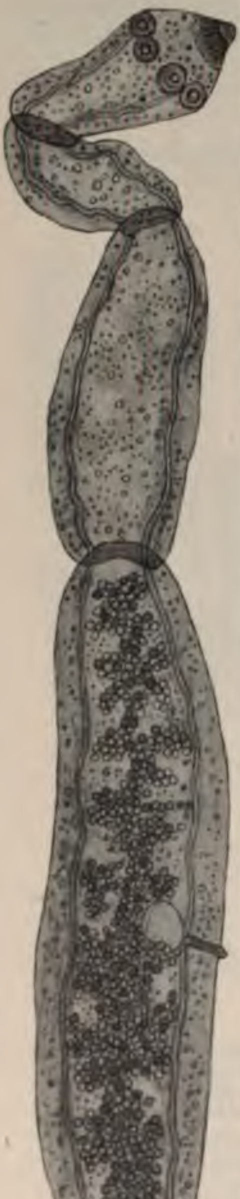


Fig. 617.—Tænia Echinococcus sexually mature, showing the Head with Rostellum and Suckers, and the three succeeding Segments, the last of which contains the Ova and other Reproductive Elements. The Water-Vascular System is likewise displayed (after Cobbold; × 30 Diams.)

varieties, is provided with a couple of elongated slit-like fossæ which act as suckers. They are placed one at each side. There are no hooklets. The joints are very slender up till the time when they become sexually mature. The intermediate host is probably a fish.

Tænia Echinococcus (Hydatids).

This parasite is the most important of all the tapeworms, on account of the scolices being often located in Man, enclosed in one or more huge cysts. These cysts go by the name of "hydatids." It is also a common disease of grazing animals.

The mature parasite is a small tapeworm, only about a quarter of an inch long, which lives in the intestine of the dog. It is possessed of four segments, and is distinguished by the great length of the last (Fig. 617). This is as long as the other three combined. The head has a pointed rostellum, with a fringe of thirty to forty hooklets at its base, and four suckers. Numerous calcareous particles are seen in the head, and there is a water vascular system running down each side of the body.

The cyst-wall or hydatid is a thick gelatinous membrane which when detached tends to curl inwards. It consists of two layers, an outer or *ectocyst* and an inner or *endocyst* (Huxley). The ectocyst is merely a chitinous envelopment, and is sometimes known as the **cuticula** on that account; the endocyst is that from which the **scolices** are developed.

These are seen projecting from its inner aspect as little wart-like bodies. They are frequently in a bunch of four or more attached to a common stem (Fig. 618, 1). They have much the same characters as the heads of the mature worm. They measure at most 3 mm. in length, and are provided with four suckers, and a fringe of hooklets as numerous as in the adult but less in size.

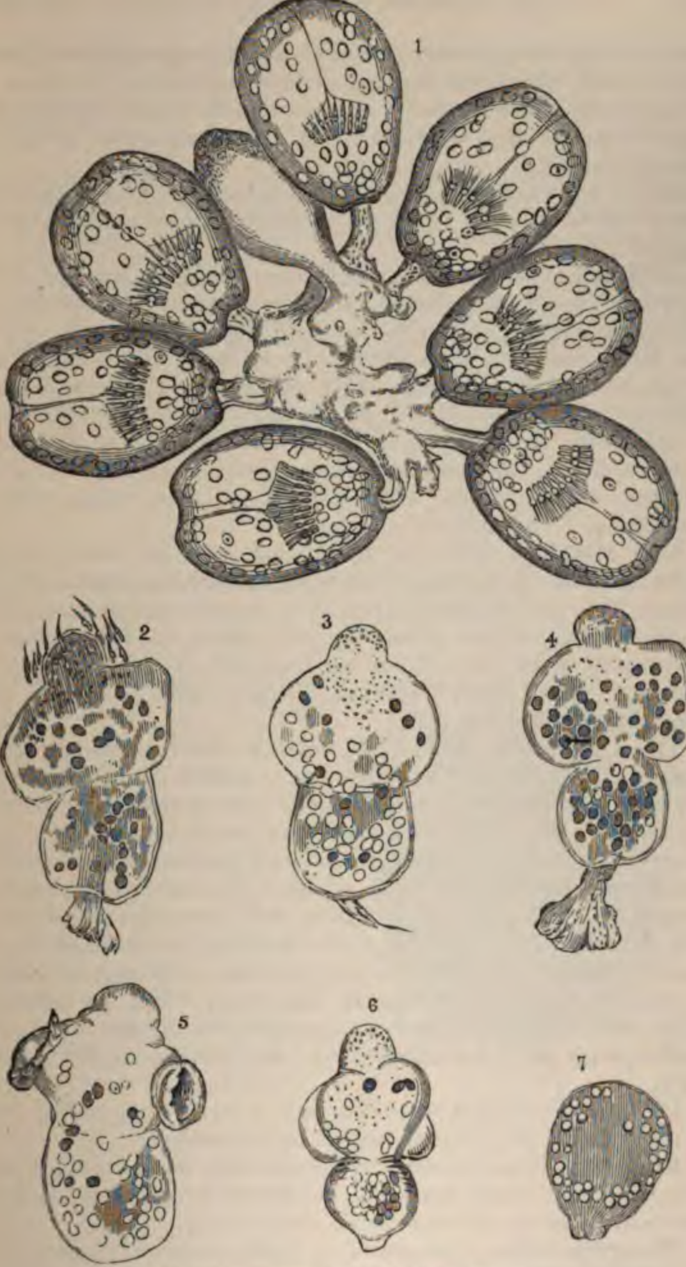


FIG. 618.—SCOLICES OF TÆNIA ECHINOCOCCUS.

(1) Group of echinococci attached by their pedicles to a portion of the collapsed wall of a brood-capsule. All the heads and cephalic hooks have remained inverted. From the hydatid of the sheep (after Busk).

These hooklets often become detached in tapping the cyst. The fact of their occurrence in the liquid is perfectly diagnostic.

The scolices have the power of retracting the rostellum, so that the fringe of hooklets may under these circumstances appear to be in the centre of the body.

The cyst is filled with clear liquid, having a specific gravity ranging from 1009 to 1015. It contains much sodium chloride but no albumin.

In Man the cyst is usually single, and continues growing until it may reach the size of a large orange or coco-nut. Sometimes, however, and more especially in the lower animals, the cyst is multilocular from the development of daughter cysts within it. In what is known as Echinococcus veterinorum, E. exogenus, or E. granulosus, the daughter cysts grow *outwards* from the wall of the parent. These have the same power of forming scolices as the original. In another variety commoner in Man the secondary cysts are developed *within the original* cyst, and sometimes even tertiary cysts are seen within these (E. endogenus or E. hydatidosus).

Life History.—The ova are cast off from the mature parasite in the intestine of the dog. Through the drinking water or other medium, they get into the stomach of a second warm-blooded animal. The six-hooked embryo is set free, and makes its way through the blood-vessels of the stomach into the liver, the eyeball, lung, brain, or some other part. There it becomes distended with liquid and transformed into the hydatid cyst.

The cyst having reached the size of about a pigeon's egg, the development of the scolices commences. A little bud-like offshoot is seen upon the interior of the endocyst. It becomes hollow, and its wall divided into two layers as in the parent cyst. There is this difference, however, as regards the relative position of the two layers, namely, that they appear to be inverted, the endocyst external, the ectocyst internal. The scolices then show themselves again in the form of minute buds upon the endocyst, which in course of time are evolved into the head of the future parasite. Although in reality on the outside of the brood-capsule, they may, owing to the capsule having undergone invagination, appear to be on the inside. The brood-capsules may accumulate to such an extent as nearly to fill the cavity.

If, again, the scolices are devoured by a carnivorous animal such as the dog or wolf, they become mature in its intestine.

Species.—From Cobbold's researches (No. 663, p. 261) it would appear that the many species of echinococcus described are all the larval conditions of the little Tænia echinococcus.

Dangers.—The cyst grows to such an extent that it affects neighbouring parts injuriously by pressure. In Man the seat of it is generally the liver, whence it may press upwards into the diaphragm, and ultimately rupture into the pleural cavity. The escaped contents excite pleurisy so severe that it often proves fatal. In other situations such as the brain or in bone the hydatid may die and the sac dry up into a cheesy mass, in which, however, hooklets may, even after long, be detected. Sometimes the rupture takes place into the peritoneum.

Literature on Hydatid Disease.—**Balding**: Hydatid Disease of Liver, 1880. **Begbie** (in Liver): Syst. Med. Reynolds, iii. **Berger**: Berl. klin. Wochnschr., viii. 1871, p. 25. **Bird**: On Hydatids of the Lung, 1877. **Bollinger** (Multiple Hydatids): Sitzungsb. d. Gesellsch. f. Morphol. u. Physiol. München, 1885, i. p. 19. **Bramwell** (in Liver): Edin. Med. Journ., xxi. 1875, p. 515. **Bumke** (in Liver): Berl. klin. Wochnschr., xx. 1883, p. 64. **Curnow** (in Lung): Trans. Path. Soc., xxxiv. 1882-83, p. 24. **Demars**: Des kystes hydatiques du foie, 1888. **Gairdner** (in Lung): Edin. Med. Journ., 1856-57, ii. p. 581. **Greenfield** (in Lung): Trans. Clin. Soc., x. 1877, p. 103. **Hartwig**: Zur Casuistik d. primären Lungenechinococcus, 1883. **Hearn**: Kystes hydatiques du poumon et de la plèvre, 1875. **Kidd** (Fatal Hæmoptysis from): Trans. Path. Soc. Lond., xxxvi. 1884-85, p. 122. **Lœvy**: Beiträge z. Casuistik d. Lungen-Echinococcen, 1885. **Murchison** (in Liver): Lancet, 1868, ii. p. 75. **Vierordt**: Abhandlung üb. d. multiloculären Echinococcus, 1886.

ARTHROPODA.

Arachnida

1156. These are mostly ectozoa. There is only one, pentastoma, which (in its larval state) occupies deeper parts.

Acarus Scabiei (the Itch Mite).

The male is only about half the size of the female, and lives either on the surface of the skin or burrows quite superficially into the epidermis.

The female is from $\frac{1}{180}$ to $\frac{1}{60}$ inch in length and $\frac{1}{125}$ to $\frac{1}{75}$ inch broad. There are four pairs of legs, and the foremost of the two posterior pairs in the male, and both posterior limbs in the female, terminate in a long bristle. Each of the two posterior in the male possesses a disc.

The female burrows deeply in the epidermis, and excavates tunnels or burrows (cuniculi) therein. Within these she deposits her eggs in linear series. In doing so she irritates the skin and causes considerable inflammation, ending in the formation of papules and vesicles. It

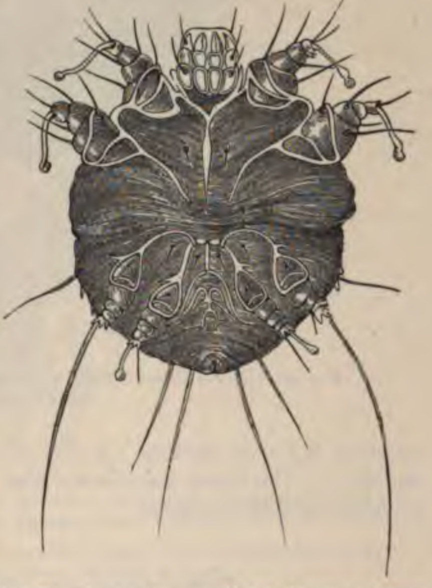


FIG. 619.—ACARUS SCABIEI (MALE)—VENTRAL ASPECT (after Kaposi).

is said that she secretes a poisonous substance which is the cause of the inflammation, but a good deal is also no doubt due to the individual scratching the part. It is said that there is hardly any skin disease which may not be simulated by the itch eruption. The flexor aspects of the arms and the interdigital skin of the fingers are the commonest seats of invasion, but in some cases there is hardly a part of the surface which can be said to be free from it. The creature is a true parasite; it dies when separated from its habitat in the skin. The lower animals are also subject to the ravages of this or an allied species of acarus.

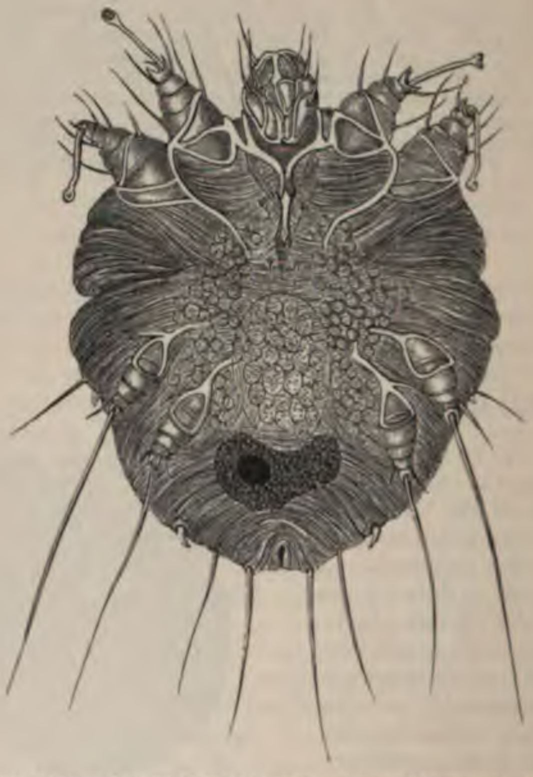


Fig. 620.—Acarus Scabiei (Female) containing Ova—Ventricular Aspect (after Kaposi).

Leptus Autumnalis (the Harvest Bug).

This is a minute spider-like creature of a red colour living naturally upon herbage. It burrows into exposed parts of the epidermis, and occasions great irritation, often ending in suppuration.

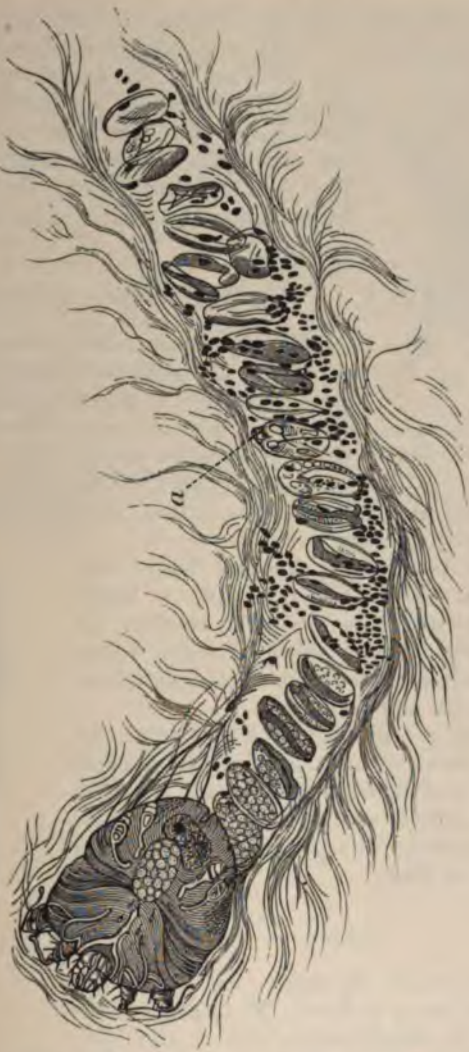


Fig. 621.—Tunnel-like Burrow of the Acarus Scabiei in the Epidermis, showing the Female with its Ventral Aspect exposed.

A ripe ovum is noticed in its interior, and behind it are twelve ova and twelve ovicapsules. The black particles are excrement (after Kaposi).

It does not procreate in the animal body, and hence can hardly be regarded as a true parasite.

Acarus (Demodex) Folliculorum.

The head resembles that of a true acarus. It has four short legs and a long abdomen. It is said to occupy the sebaceous glands in acne of Man, but the frequency of its occurrence within them has apparently been a good deal exaggerated. It is the cause of one of the commonest forms of mange in the dog. The ova are deposited in the skin. Their destruction is a matter of great difficulty.

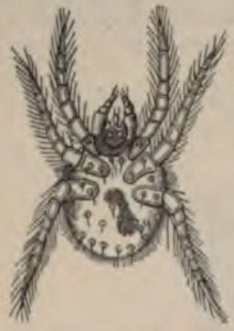


FIG. 622.—LEPTUS AUTUMNALIS (HARVEST BUG) [after Küchenmeister].

Pentastoma Tænoides seu Denticulatum.

Sharply circumscribed yellow tumours are sometimes met with protruding from the surface of the liver, or embedded in its substance, and sometimes scattered diffusely over the peritoneum of old people. They have a tough capsule and cheesy or calcareous contents, and vary in size from a millet seed to a pea. They contain the larval phase of the above parasite.

The larva possesses a rounded body with annular rings, almost like those of a tænia, amounting, it may be, to ninety in number. It is provided with four hooklets arranged round the mouth, each provided with a chitinous hood into which it can be retracted.

The mature parasite is of a lancet shape, the female from 60 to 85 mm., the male from 16 to 18 mm. long, and about 3 mm. broad. It lives in the frontal sinuses and nares of the dog where the ova are ejected. It is occasionally parasitical in the nostril of Man.

Insecta.

1157. The most important members of this group are the lice or pediculi. **P. capitis** or the head louse, **P. vestimentorum** or the body louse, and **P. pubis** or crab louse, are the three varieties which are parasitical on Man. Their ova are cemented on to the hairs, and are detached consequently with difficulty.

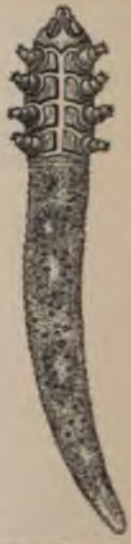


FIG. 623.—DEMODEX FOLLICULORUM (after Perls; × 300 DIAMS.)

Cimex lectularius is the ordinary bed bug; **Pulex irritans** the common flea; while **Pulex penetrans** is the name given to the sand-flea or chigoe of North and South America.

GENERAL LITERATURE ON ANIMAL PARASITES.

Allen (Parasitic Hæmaturia): Practitioner, xl. 1888, p. 310. **Clarke** (Psorosperms in Adenoma of Cat's Lip): Brit. Med. Journ., 1893, i. p. 951. **Cobbold** (Olulanosis of Cats): Veterinarian, lviii. 1885, p. 526. **Delépine** (Psorospermiæ in Liver): Brit. Med. Journ., 1889, ii. p. 1393. **Freeman** (Psorospermiæ): Proc. N. Y. Path. Soc. (1889), 1890, p. 93. **Galloway** (Influence of Protozoa in Disease): Brit. Med. Journ., 1892, ii. p. 1433. **Harrison** (Bilharzia): Lancet, 1889, ii. p. 163. **Hertz**: Cycl. Pract. Med. (v. Ziemssen), v. 1875, p. 462. **Kartulis** (Pathogenic Protozoa): Ztschr. f. Hyg. u. Infectionskrank., xiii. 1893, p. 1. **Klein** (Relation of Russell's Fuchsin Bodies to Altmann's Cell Granules): Beitr. zu path. Anat. u. z. allg. Path., xi. 1891, p. 125. **Lutz** (Amœba-Enteritis): Centralbl. f. Bakteriol. u. Parasitenkrankh., x. 1891, p. 241. **Merk** (Psorospermosis): Mitth. d. Ver. d. Ærzte in Steiermark, xxx. 1893, p. 161. **Nasse** (Amœba in Hepatic Abscess): Arch. f. klin. Chir., xliii. 1892, p. 40. **Pfeiffer** (Gregarinidæ): Ztschr. f. Hyg., viii. 1890, p. 309; *also*, Die Protozoen als Krankheitserreger, 1890; *also*, Beiträge zur Protozoen-Forschung, 1 Hft. Die Coccidien-Krankheit der Kaninchen, 1892. **Posner** (Amœba in Urine): Berl. klin. Wochnschr., xxx. 1893, p. 674. **Power** (Production of Cancer): Journ. Path. and Bacteriol., i. 1892-93, p. 495. **Ranke**: Pulm. entozoic Disease of Sheep, Trans. Path. Soc. Lond., ix. 1857-58, p. 456. **Rosenberg** (Psorospermia in Muscle of Heart): Ztschr. f. Hyg., xi. 1891-92, p. 435. **Ruffer and Plimmer** (Further Researches upon Protozoa of Cancer): Journ. Path. and Bacteriol., i. 1892-93, p. 395; *also*, Reprint. **Steven and Brown** (Parasitic Protozoa of Cancer): Journ. Path. and Bacteriol., Oct. 1893; *also*, Reprint. **Sutton** (Psorospermiæ in Ureter): Brit. Med. Journ., 1889, ii. p. 1392. **Touton** (Russel's Fuchsin Bodies and Goldmann's Spherical Cells): Arch. f. path. Anat., cxxxii. 1893, p. 427. **Willach** (Nature of Coccidia): Arch. f. wissensch. u. prakt. Thierh., xviii. 1892, p. 242.

PART V

ANIMAL HEAT AND FEVER

CHAPTER XCVIII

ANIMAL HEAT AND FEVER

1158. ALTHOUGH researches upon the subject of animal heat in reality commenced with Lavoisier, we are even yet far from having a satisfactory understanding of the matter. More especially is this the case in the domain of fever. For as most fevers are caused directly or indirectly by the presence of parasitical microbes, it can be readily understood that many new fields of research in pyretology have been opened up by our increasing knowledge of their habits and pathogenic properties.

Facts like that of the glycerine extracts of tubercle and glanders cultures exerting such a profound and specific influence over the heat-producing and other metabolisms of the tubercular or glandered animal, and not over those of the same animal in health, are themselves suggestive of fresh inquiry.

We inject a quantity of putrid liquid into the circulation of an animal; the animal is thrown into a state of fever and may die. Still we have little idea of how the putrid agent excites the fever, whether it acts by suppressing the normal excretions and causing a poison to be retained which stimulates the heat-regulating mechanism, or whether it contains something which of itself influences the thermal areas in the brain and lower nerve centres, or, mayhap, has a direct action upon the heat-generating tissues themselves.

These and other such like speculations must open up to the reflective mind lines of investigation as yet practically untouched, and which until followed out must render the subject of the pathology of fever always more or less unsatisfactory.

THE NORMAL TEMPERATURE OF MAN AND OTHER ANIMALS.

1159. Animal life is capable of existing only between the temperatures of 0° C. and 45° C. The lowest temperature at which Man can survive is 24° (Reinke), the highest between 44° and 45° C. Wunderlich records a reading of a temperature of 44·75° C. (112·55° F.) in an individual suffering from tetanus, but this is quite phenomenal, and the person died shortly afterwards. Instances of temperatures recorded as above this are to be regarded with suspicion, as due to error in the observer or to deception on the part of the observed.

There is a certain, although not very great, discrepancy in the readings given of the average **rectal** temperature of Man. Thus, according to Richet (No. 657, p. 64)—

Jürgensen makes it	37·7° C.
Wunderlich	37·35 „
Jäger	37·13 „
Oertmann	37·19 „
Redard	37·65 „

The discrepancy may, however, be accounted for by the fact that the quotidian temperature varies at different times.

The average temperature in the **axilla** is 36·99° C. (practically 37° C. or 98·6° F.). It is much higher than cutaneous temperatures, from the fact that, as usually taken, the reading does not represent the temperature of the surface, but of the textures an inch or so below the skin.

The **cutaneous temperatures,** as ascertained by J. Davy (No. 321), are as follows. The observations were made on himself while standing naked with the temperature of the room at 21° C. He found that of the skin to be as follows. Only the under surface of the thermometer was allowed to touch the skin.

Middle of the sole of the foot	32·26° C.
Near tendo Achillis	33·85 „
Anterior surface of leg	33·05 „
Middle of calf	33·85 „
Bend of knee	35·00 „
Middle of upper arm	34·40 „
Inguinal fold	35·80 „
Near cardiac impulse	34·40 „

The temperature of the **mouth** under the tongue is from 37 to 37·7 C. (Gassot), that of the vagina 38·3 C. The internal temperature of the body may be readily taken by micturating over the thermometer bulb. The temperature of the **urine** is that of internal parts (about 37 C.).

The mean temperature of the **blood** is about 39 C. The blood of the *right side of the heart* is warmer than that of the left side, a fact said to be explained in part by the high temperature of the liver (41·25 C. in the sheep). The blood of the *hepatic vein* comes up to 39·7 C. Although the temperature of the blood on the venous side of the heart is higher than that on the arterial, the same does not hold good for the venous blood in peripheral parts, the temperature of which is lower than the arterial.

The temperature of the **tissues** rises in accordance with the activity of the metabolism going on in them, the quantity of blood they contain, and the distance they lie from exposed parts. It is pretty universally conceded that the **brain** is the warmest organ in the body.

In the **child,** up to nine years, the mean temperature is somewhat higher than in the adult, and the newly-born child is warmer than the vagina of the mother.

The temperature of the **horse, donkey,** and **ox** is 37·5° C. to 38° C., of the **sheep** and **rabbit** 38° to 39·5° C., and of the **mouse** 40° C. (Munk). **Birds,** it should be remembered, have a relatively high temperature, that of the common fowl and pigeon being 42° C. The temperature of **fishes,** like that of other cold-blooded animals, varies with the temperature of the medium in which they are immersed, but is usually about ·05° to ·1° C. above that of the water. **Amphibians** (the frog) have a temperature usually about 1° C. above that of the surrounding medium, and **reptiles** from 1° to 4° C. above the temperature of the air (M'Kendrick, No. 32, ii. p. 438).

Diurnal Variation.—The temperature of the body as measured in the rectum or axilla is not the same at every period of the day. There comes a rise with the afternoon hours, and a fall again up to the early hours of the morning. It appears to be highest between the hours of three and six in the afternoon (37·5° C., Jürgensen), and lowest (36·7° C.) between three and five o'clock in the morning (Jürgensen, Liebermeister, Richet). The *mean* diurnal temperature is therefore, under ordinary circumstances, higher than the nocturnal; there is a difference of something like ·4° C. It may happen, however, that this relationship is reversed, and mostly so in those who work during the night instead of during the day (Richet).

The elevation of temperature in the afternoon is said to be due to the inception of nourishment and to muscular exercise. But the falling off in the evening ensues in spite of the principal meal of the day being taken at this time. In fever, moreover, notwithstanding that the individual is on fever diet and lying in bed, the same rise in the afternoon is invariably noticed. Hence objection has been taken to the theory of extraneous circumstances being the cause of it.

According to Richet (No. 657), it cannot be due entirely to diet, although to a certain extent it is influenced by it. He traces it rather to the nervous system being at this time of the day in full functional activity.

A remarkable fact, as brought out by Jürgensen's researches, is that the mean temperature of the human body in the twenty-four hours is remarkably independent of conditions which temporarily affect it. Thus, if from any cause the temperature be suddenly raised, the excess of temperature is compensated for, as it were, by a corresponding fall. This fact has been taken advantage of by Liebermeister in accounting for the natural fall which takes place in the evening after the rise in the afternoon. It is a compensatory measure.

Influence of Temperature of Surroundings on that of the Body.

From a temperature point of view there may be said to be two kinds of beings, namely, (1) those whose temperature varies with the surroundings; (2) those whose temperature is practically constant whatever the external temperature may be. The former are known as cold-blooded or poikilothermal animals. Their combustion is low, and they are devoid of the power of regulating it according to circumstances. Hence they perish if the temperature of the ambient medium differs much from that of their bodies. The latter are known as warm-blooded or homoiothermal animals. They are provided with a heat-regulating nerve mechanism, as yet, however, not well understood.

The peripheral temperature of the warm-blooded animal changes only slightly in accordance with that of the surroundings. The temperature of internal parts does so also, but even to a less extent. So that if the buccal temperature varies 2·5° C. owing to change in the temperature of the surroundings, that of the rectum varies not quite 1° C. (Richet, No. 657, p. 104).

And even these variations, due to the temperature of the enveloping medium, are not durable. In passing from a cold to a warm district the temperature may rise for the time being, but soon comes back to the normal. Travellers from England to India experience at first a rise of temperature to 38° C., but before long it returns to the normal. It is no doubt possible to survive a body temperature of 43° C. or a little above it. In hot countries, however, the temperature of the atmosphere may come up to 50°, 60°, or even 80° C., and yet the temperature of the body in those acclimatised to it not reach beyond the normal.

The same high temperature cannot be borne in a moist as in a dry atmosphere. The reason is that, in the moist atmosphere, transpiration does not go on so freely as in the dry, and hence the body cannot relieve itself of its extra heat through this channel.

Sources of Animal Heat.

They are chiefly the combustion or oxidation of the carbon, hydrogen, and other elements of the body within the tissues. Indeed, most of the chemical interchanges occurring in the body are accompanied by the evolution of heat. The performance of mechanical work, of intellectual work, and the act of secretion from glands are all accompanied by the liberation of heat. Electrical currents in muscles are transformed into heat, and there are several minor sources from which it is also derived.

Danilewsky and Rubner (No. 49, 1885, i. p. 190) give the following combustion equivalents of various articles of diet. For 1 of dry substance they find the following equivalent in calories :—[1]

Casein and blood-fibrin	5772-5855	(D)
Vegetable fibrin	6231	(D)
Albumin	5754	(R)
Muscle	5345	(R)
Hæmoglobin	5949	(R)
Peptone	4900	(D)
Fat	9423 (R) 9686	(D)
Cow's milk	5733	(D)
Bread	4351-4471	(D)
Rice	4806	(D)
Peas	4889	(D)

It would thus appear that in the process of hydration necessary to convert albumin into peptone it loses from 16 to 18 per cent of heat-producing power.

They have also calculated the heat equivalents of the various excreta, which they find to be as follows :—

Urea	2523 (R) 2200	(D)
Albuminous urine	2706	(R)
Urine from meat diet	2954	(R)
Starvation urine	3101	(R)
Fæcal matter from albuminous diet	5722	(R)
,, ,, ,, meat ,,	4850	(R)

Deducting the heat lost in the excreta, etc., Rubner finds the percentage utilisable heat of articles of diet to be as follows :—

Albumin	78·6
Muscle	79·9
Materials utilised during starvation	71·9
Fat	100

According to Danilewsky, 100 grm. casein is equivalent in heat-producing power to 51 grm. fat, 133 grm. starch, 151 grm. grape-sugar, or 121 grm. peptone.

Alcohol does not cause increase, but, on the contrary, decrease of the body temperature. This result is accounted for probably by its expanding the superficial vessels, and thus allowing increased radiation from the skin. Whether taken in by the stomach or injected into the blood, it is, according to Wolfers (No. 169, xxxii. 1883, p. 222), partially oxidised within the organism. The consumpt of oxygen is markedly augmented, and so is the quantity of expired carbonic acid. Alcohol, however, does not interfere with the general processes of oxidation, the lowering of the temperature being due, not to lessened oxidation, but to the heat parted with being greater than the excess formed under its sway.

The Localities in which Heat is generated.

1160. Although, as above indicated, wherever oxidation is proceeding heat is being liberated, yet the muscles must be regarded as the great seat of its generation (Samuel). Constituting as they do something like half the bulk of the body, there is ample scope within their substance for the generation of by far the greater part of the entire animal heat. We regulate our temperature by means of the muscles. When cold we cause them to contract, when warm we allow them to remain relaxed. In tetanus the temperature rises when the muscles are in a state of spasm, and again falls when the spasm is relieved by the administration of chloral.

---

[1] By a kilogramme-unit or calorie of heat is meant the amount necessary to raise the temperature of a kilogramme of water 1° C., or, strictly speaking, from 15° to 16° C. The symbol Ca is employed to indicate it. A small calorie means the $\frac{1}{1000}$ part of a Ca, or the heat required to raise 1 grm. of water 1° C.

How it is that the heat is produced within the muscle is a difficult problem to solve. Liebig's notion was that the muscles themselves were burned, and that heat was generated therefrom. Possibly, where the available supply of nourishment is small, as in a person on fever diet, this is so. But when the blood is rich in proteids and hydrocarbons the conditions are altered. Is the proteid matter supplied to a muscle by the blood first converted into muscle before it is oxidised? Or does it undergo combustion simply within the muscle substance independently of being transformed into myosin? And if it is the case that the muscle is actually consumed, and that this is the great source of heat in the body, where does the oxidation of the hydrocarbons and carbohydrates of the food take place? All this is as yet uncertain. Our knowledge of what happens to the various food elements practically ceases the moment they enter the blood.

Mosso (rep. by Richet, No. 657) has made some precise observations on the effect of muscular exercise on temperature. He first of all measured his rectal temperature at different hours of the day. The readings were at

6 o'clock in the morning	36·45° C.
8 ,, ,, ,,	36·98° ,,
10 ,, ,, ,,	37·06° ,,
Noon	36·93° ,,
2 o'clock in the afternoon	37·25° ,,
4 ,, ,, ,,	37·07° ,,
6 ,, ,, ,,	37·3° ,,
8 ,, ,, ,,	37·14° ,,

During a walk of 100 kilomètres in two days he found that the following were his temperatures, the temperature of the atmosphere being from 12° to 19° C.

	First day of walk.	Second day of walk.
6 o'clock in the morning	36·3°	36·7°
8 ,, ,, ,,	37·8°	38·2°
10 ,, ,, ,,	37·65°	38·1°
Noon	37·8°	38·3°
2 o'clock	37·5°	38·4°
4 ,,	37·8°	38·5°
6 ,,	38·2°	38·8°
8 ,, (reposed)	37·3°	38·4°

It is evident that this comparatively slight elevation of temperature is not in keeping with the great amount of work done. According to Mosso, it is not the musculature but the nervous system which produces hyperthermia. Still it is to be borne in mind that *the mere temperature of the body is not necessarily a correct index of calorification.* During violent exercise, such as that indicated in the above experiments, the loss of heat by radiation, sweating, etc., must have been great.

Although the heat produced by a muscle and the work done by it are in close relationship, yet in some respects the heat-producing and the contracting mechanisms may be looked upon as in a manner separate and distinct. According to Macalister (No. 6, 1887, i. p. 609), the effect of stimulating a muscle is twofold. On the one hand, the phenomena are explosive, as manifested in the change of form and performance of mechanical work; on the other hand, they are more continuous and manifest themselves by increased development of heat. Each process has its own laws and is independent of the other. The heat is not to be regarded as a thermo-dynamic waste product, an excretion of no greater dignity than urea or carbonic acid. The thermogenic stuff, as it were, is different from the contractile stuff. The muscle gets fatigued as a heat-producer long before it gives in as a work-producer.

Maintenance of Equilibrium of Temperature.

1161. This is effected by the adjustment of heat production and heat dissipation. If the heat production be too great, it can be lessened either by partial inhibition, or by increased escape of the superfluous heat from the surface of the body, from the lungs, or from both. The skin, no doubt, is the great safety-valve in preventing overheating of the body. Heat escapes through it either by being led off through the intermediation of space, that is to say, by radiation, or by passing from particle to particle, that is to say, by conduction. When the internal temperature rises abnormally the cutaneous vessels become relaxed, and from them an increased quantity of heat escapes into the surrounding atmosphere. If, on the contrary, the heat production of the body be slight and the surroundings cold, the cutaneous vessels contract and the loss of heat by radiation is lessened.

If both cervical sympathetics are divided, so great does the radiation of heat from the relaxed cutaneous blood-vessels become that the temperature of the body may fall a couple of degrees (Cohnheim). It returns to normal when the vessels regain their tone. Drunken men cool more easily than those who are sober, owing to the relaxation of their cutaneous vessels.

Varnished animals die from the fall that takes place in their temperature. The cutaneous vessels dilate and the varnish acts as a good conductor. The internal temperature consequently sinks.

The sudden contact of cold air with the surface of the body, on the other hand, may cause the internal temperature to rise from 1 to 2 degrees.

Part of the extra heat is also dissipated in the sweat and in the various excreta.

Something like 80 per cent of heat of the body is lost through radiation, conduction, and evaporation, and of this about 60 per cent is dissipated by radiation alone. Less than 20 per cent escapes through the organs of respiration.

Radiation is more intense where metabolism is most active, in men than in women, in boys than in girls, in young rather than in old people, and in the robust rather than in the weakly.

Where the accommodating thermic system is unable to cope with the heat of the surrounding atmosphere, the temperature rises inordinately (42°-44° C.), and gives rise to the phenomena known as **heat-stroke, sun-stroke,** or **insolation.**

Heat Production and Temperature.

1162. From what has just been remarked about the maintenance of a heat equilibrium it will be gathered that the thermometer is no index of the heat actually generated in the system. It informs us merely of the mean heat or **temperature** of the body resulting from the generating capacity on the one hand, and the loss through various channels on the other. The heat production is greatest sometimes when the temperature is lowest. Methods of **calorimetry** must be adopted in order to ascertain the heat-forming capacity of an animal. In animals, numbers of such observations have been made, but our knowledge of the subject in Man is limited owing to the great technical difficulties of the investigation.

Nervous Mechanism for the Regulation of Temperature.

1163. The opinion is becoming more and more assured that the regulation of the heat of the body is largely if not entirely under the control of the nervous system. There appear to be areas located in the spinal cord, in the medulla oblongata, in the pons Varolii, and in the cerebral cortex which either directly or through the vaso-motor nerves regulate the greater or less output and loss of the heat of the body. Hale-White (No. 193, xxxvi. 1886, p. 4) thinks it likely that those situated in the cerebral cortex are not merely musculo-vaso-motor in function, but are genuinely calorific. Wood's experiments (No. 659), on the other hand, tend to show that a great deal of the control is exerted through the vaso-motor nerves. Section of the spinal cord above the origin of the splanchnic nerves is usually followed by an immediate and very decided increase in the amount of heat dissipated from the body, and also by a decided lessening of the amount of heat produced (p. 45). The only nerve centre, he states (p. 254), capable of influencing the heat production without affecting the general circulation, is situated in the pons or above it, and whilst it may be a muscular vaso-motor centre, it is more probably an "inhibitory heat centre." Of whichever nature it may be, it must act through subordinate centres situated in the spinal cord. So far as our present knowledge goes, the chief factor in controlling heat dissipation is the vaso-motor nerves, including in Man such nerves as control sweat secretion. These nerves are able, by contracting the capillaries of the surface of the body, and by drying the secretion of the skin, to reduce the loss of heat to a minimum, and by a reverse action are capable of increasing it to a maximum.

That heat-controlling centres exist has been demonstrated experimentally on animals and accidentally in Man. In the brain of the rabbit at least four such centres have been found which, when stimulated, occasion increased heat production, not mere rise of temperature. Two lie at the anterior median border of the corpus striatum, one between this and the thalamus, and one, it is said, at the anterior end of the thalamus. Hale-White, however (No. 179, xii. 1891, p. 251), denies that the body of the thalamus has any function in raising the temperature, while he affirms that in addition to the corpus striatum this function is resident in the septum lucidum. Injury of the posterior region of the upper surface of the cerebral cortex in the rabbit may cause irregular rises in temperature; these are quickly produced and last only a short time. Injury of the crus cerebri occasions a considerable rise of temperature.

Aronsohn and Sachs (No. 169, xxxvii. 1885, pp. 232, 625) have used various animals as subjects for experiment, but mainly rabbits. They trepanned the skull in the angle between the coronal and frontal sutures. The operation was performed with antiseptic precautions. A needle was used for puncturing the brain. The needle encountered in its course (1) the cortex, (2) the white substance of the frontal lobe, (3) the mesial side of the head of the corpus striatum in the vicinity of Nothnagel's nodus cursorius, and (4) the basal white and gray matter. The puncture is useless unless it runs through (3) and (4). It must strike the particular part of the corpus striatum mentioned under (3). The maximum elevation of temperature occurs in from two to seven hours after puncture. It takes from twenty-four to seventy-three hours when the puncture affects the corpus striatum alone. The elevation of temperature is accompanied by increased frequency of pulse and respiration. Several days after the operation the temperature, pulse, and respiration are normal, but can be again raised by a fresh puncture. The researches seem to point to the possibility of a nervous fever without fermentation or chemical interchange.

Richet (No. 40, xcviii. 1885, pp. 827, 1021; *also*, No. 169, xxxvii. 1885, p. 624) found that when the frontal region of the brain of the rabbit is punctured with a needle so as to avoid the basal ganglia, the rectal temperature rises several degrees. The rise follows after several hours and does not seem to injure the animal. It follows also after cauterisation of the brain. He satisfied himself that the elevation was due to increased production, not to diminished waste of heat. Animals in which the high temperature continues for days eat heartily, but in spite of this, become emaciated.

Hale-White, however (No. 179, xii. 1891, p. 252), asserts that lesions of the anterior part of the upper surface of the cerebral cortex either do not alter the temperature or the alteration is very slight.

In the dog, severe injury of certain parts of the cerebral cortex, more especially just posterior to the crucial sulcus, is accompanied not merely by rise of temperature but by increased production of heat.

Lesions of the pons in Man are well known to be followed by high temperature.

How it is that lesions of the cerebral cortex induce the elevation of temperature is not settled. Quite possibly the centres in this locality exert a controlling influence on those lower down.

FEVER.

Definition.

1164. Our knowledge of the pathology of fever is as yet too limited to serve as a basis for a strict definition of what is meant by it. Since the days of thermometry it has been the custom with some physicians to call any rise of temperature by this name; in fact, to speak of so many degrees of fever according to the height to which the mercury in the thermometer rises. Such was certainly not the original application of the term. To the older physicians the term *fever* meant a complex of symptoms in which, although the subjective feeling of heat was certainly one of the most prominent, many other symptoms equally remarkable were to be observed. The term, moreover, was usually applied to a condition ushered in by initial symptoms running a definite course and terminating in a particular way. It is probable that this old-fashioned view may yet come to be the basis of our future definition, that true fevers will be regarded as invariably the manifestations of processes allied to, if not identical with, fermentations, and that mere elevation of temperature and true fever will in no wise be confounded as at present they often are. We have perhaps no more right to call a temporary hyperpyrexia by the name of fever than we have to call a passing increase of the colourless corpuscles of the blood a leucocythæmia. Increase in the number of leucocytes is characteristic both of leucocytosis and of leucocythæmia, yet no one would think at the present day of confounding these two conditions. All the length we can go at present in the way of defining fever is in asserting that it is a process in which tissue metabolism is excessive and in which the temperature of the body is above the normal.

Stages.

There are three. The first is known as the **pyrogenetic** or **initial.** In this the individual experiences usually a sensation of cold accompanied by shivering. Yet the temperature is above the normal and is rising. It is accompanied by headache and other signs of constitutional disturbance.

The second is the stage of so-called **fastigium** in which the fever is at its height, and in which the loss of appetite, headache, and general malaise are pronounced. The temperature may exhibit certain fluctuations, reaching its highest point on several occasions and showing slight depression in the interval. The skin feels hot to the hand of the observer laid upon it, and is redder than usual. The feeling of heat is due chiefly to increased radiation. In the previous stage, while the shivering is on, the skin is blanched and feels cold. In this, the red vascular skin acts as a good conductor, better than the blanched white skin, another reason for its feeling hot to the touch.

The third stage is that of **defebration** or **defervescence,** in which the body heat returns to the normal and the other functions reassume their normal type. For some time after the third stage the temperature may remain subnormal.

If the fever symptoms disappear suddenly, say within thirty-six hours, the fever is said to end by **crisis.** If the temperature comes down more gradually and the other symptoms disappear slowly, it is said to terminate by **lysis.** The ending by crisis is usually accompanied by profuse sweating, and by the copious deposition of lithates from the urine.

Temperature.

Certain terms are applied to the fever according to the height of the temperature. The temperature may range from normal up to 114° F. Wunderlich adopts the following classification (Fagge, No. 660):—

1. Subfebrile, temp. 99·5°-100·4° F. (37·5°-38° C.)
2. Slightly febrile, temp. 100·4°-101·3° F. (38°-38·5° C.)
3. Moderately febrile, temp. 101·3°-102·2° F. in morning; 101·3°-103·1° F. in evening (38·5°-39° C. in morning; 38·5°-39°·5 C. in evening).
4. Decidedly febrile, temp. about 103·1° F. in morning, about 104° F. in evening (39·5° C. in morning, 40·5° C. in evening).
5. Highly febrile, temp. above 103·1° F. in morning, above 104·9° in evening (39·5° C. in morning, 40·5° C. in evening).
6. Hyperpyretic, temp. approaching 107·6° or even higher (42° C.)

The cause of the high temperature has met with various explanations from time to time. As yet, even the statements and alleged facts bearing upon it are to a large extent contradictory. There are in the main **three possibilities,** namely, (1) as was supposed by Traube (No. 316), *that the amount of heat generated is not in excess, but that the discharge from the skin owing to contraction of its arterioles is* *diminished*; (2) *that the discharge from the skin remains the same as or is less than in health, but that there is increase of production*; and (3) *that there is both increased production and increased discharge, but that the gain from the former supersedes the loss from the latter.* The first of these possibilities was said to be refuted by the observations of Senator, Leyden, and, later on, of Wood (see Bibliog.), to the effect that the discharge of heat from the skin is in reality greater than usual. The heat, it is said, is not retained abnormally; it is alleged, on the contrary, to be discharged to excess in all stages. On the face of this the observations of Leyden, Ranke, and others seemed to show (Sanderson, No. 193, xvi. 1876, p. 341) "that although, as compared with the heat production of an individual on fever diet, the heat production of a fevered person is excessive, it is not by any means greater than the heat production of health." It is even said that the normal production of heat may be made to far exceed that of fever. If these two statements are correct, if the output on the one hand is increased, if the production is not above that of health, and if the discharge from other channels is not decreased, as it is assumed it is not, how comes it that the temperature rises above the normal? There is an inconsistency here which shows how insufficient the conclusions as yet arrived at by experiment are to explain the facts of hyperpyrexia.

The statement that the discharge of heat is increased from the skin, not decreased, seems to be only partially true. There are the best reasons for believing that, during the initial stage of the fever, in Man at least, it is very considerably decreased. The feeling of cold imparted to the hand of the observer when placed over peripheral parts alone would indicate either that this is so or that the skin, for some reason, has become a better conductor, and thus imparts to the hand a subjective sensation of cold. There is no reason why it should be a better conductor; on the contrary, the blanched white skin ought to be a less perfect conductor than skin which is in its natural state of redness.

Surface thermometry, moreover, bears out the allegation that in most cases of fever, instead of there being an agreement between the skin temperature and that of internal parts, there is a decided disagreement. As the one rises the other sinks. And here it must be remarked that excessive care must be taken in recording surface temperatures. There is great liability to error in taking them. What is often called the surface temperature is in reality not that of the surface, but of the parts at some distance underneath. Schulein's observations (No. 13, lxvi. 1876, p. 109) clearly show that in the stage of shivering the feeling of cold is not merely subjective, but that the temperature of the skin sinks, while that of the axilla rises. In the case of typhoid, peritonitis, acute rheumatism, erysipelas, puerperal endometritis, miliary tubercle, and cheesy pneumonia, he finds that the temperature of the axilla and that between the toes do not correspond, that, while the axillary temperature rises, the peripheral temperature falls. In an instance given of intermittent fever, the chart showed that, while the axillary temperature went up to 40° C., that taken between the toes fell simultaneously to between 24·6° and 25° C. Exceptions are found in the instance of croupous pneumonia, measles, and scarlet fever. Here the temperature of the skin rises pretty regularly with that of the axilla, and in scarlet fever and pneumonia he has ascertained that the relationship remains constant. The cause of the diminished temperature of the surface is that the blood-vessels are in a state of tonic contraction, and that less blood is passing through them.

That there are cases in which the discharge from the skin is lessened and in which the production is normal seems doubtful. The increased production seems to commence with the initial stage of the fever.

The third possibility is one which apparently is an actuality. Cases have just been referred to in which the skin temperature from the commencement keeps pace relatively with that of internal parts. The high temperature in these cases is probably to be explained by the heat production being so great that it more than compensates for the increased loss by the skin and other channels. In the later stages of fever also more heat is undoubtedly lost through the skin than in health, and yet the temperature remains high. The most feasible explanation of the high temperature under such circumstances would seem to be founded on this last of the three mentioned possibilities.

Conclusions.—In summing up the arguments on the one side and on the other to account for the rise of temperature in fever, it would seem that it is not always due to the same cause or train of causes. In the initial stage of most fevers the rise of temperature is probably accounted for by slightly increased production and by diminished waste from the cutaneous vessels being in a state of spasmodic contraction. In the later stages of fever, when this spasm has been succeeded by relaxation, more heat is lost through the skin than in health, and vastly more than in the stage of shivering. The production of heat, however, is so great that not only is this loss compensated for, but the body temperature is raised. There are still other cases where apparently this second source of high temperature prevails from the commencement. In the third stage, the escape of heat directly through the skin and in the sweat is very great, so great that unless the amount of heat produced continues in excess, the temperature may come down lower than in health.

Rhythm of Fever Temperature.

1165. Although in fever the temperature is high, yet there is this to be said about it, that it follows the daily normal curve. Place the temperature chart of a case of typhoid fever taken hourly side by side with one taken from a sound person, and it will be found that the curves are alike. There is the same rise in the afternoon and fall in the early morning in both. The only difference is in the matter of height; the fever temperature is set, as it were, at a higher level than that of health.

TRAUMATIC FEVER.

1166. Hyperpyrexia can be excited by a number of agencies which probably act by reflex stimulation of the heat centres. Thus a simple fracture of a bone or the passage of a catheter is sufficient to send the temperature up several degrees. The amount of hyperpyrexia which accompanies inflammation and suppuration is not always proportionate to the extent of the part involved. An inflamed tonsil will sometimes occasion a higher temperature than a much more extensively outspread inflammation. *Tension* from the oldest times has been recognised as a cause of fever. A few drops of pus pent up in tense fibrous surroundings will excite severe fever—a fever almost instantaneously relieved by a free incision into the part.

The fever in such cases is out of all proportion to the extent of the injury; the tension of the surrounding tissues must have something to do with its excitement. The probability is, as just remarked, that the heat-controlling centres are stimulated reflexly by the peripheral irritation. It cannot be, even where the part is suppurating and where the pus is pent up in a capsule, that the symptoms are entirely due to poisons absorbed from the part, because in wounds which are kept aseptic, as Horsley remarks (No. 6, 1885, i. p. 420), the same elevation of temperature is sometimes noted. Volkmann and Genzmer (Nos. 114, 121; Chir. 37) have supposed that in such subcutaneous injuries as simple fracture a pyrogenous substance is liberated from the injured tissues which accounts for the traumatic fever. The mere accumulation of blood in such a torn part will cause elevation of temperature several degrees,—a fact which might be held as favouring such a theory.

But injury of a tissue is unnecessary in the causation of mere hyperpyrexia. Mental emotion, such as the admission of a distressing case of injury into the ward of a hospital, will sometimes send the temperature of a timid patient up a degree or two.

Lastly, as alluded to in the commencement of this chapter, we may be said to be almost completely in the dark as to how the majority of the true fever poisons act. Judging by the analogy of the action of substances which induce hyperthermia, these poisons are probably of a chemical nature. Martin supposes that in anthrax the albumoses formed by the bacillus are the fever-exciting agents, the alkaloids the coma-producers.

THE PRODUCTS OF FEVER METABOLISM.

1167. **Urea.**—Sanderson (No. 193, xvi. 1876, p. 267), basing the calculation on three observations by Unruh, makes the statement that

17·466 grms. (270 grains) may be regarded as the normal daily discharge of urea from a healthy individual on fever diet and lying in bed. The amount may be otherwise expressed by saying that it comes up to something like 0·3835 grm. per kilo of body weight. The average in a healthy individual under ordinary conditions is about half a gramme. We may therefore take 0·38 grm. per kilo as the normal low diet discharge of urea in health. In fever, Unruh found it to rise as high as 65·97 grm. daily, or 1·18 per kilo weight of body—an amount more than three times that of a healthy individual under like conditions. The lowest amount he obtained was 18·6 grm. per diem. The average of the whole series of observations was 30·576 (= about 470 grains).

It is evident, therefore, that, notwithstanding the peculiar conditions of the patient as regards diet and forced rest, the tissue metabolism must be proceeding at a rate above that of a healthy individual under the same circumstances. A healthy person, however, on mixed full diet and not lying in bed, discharges from 30 to 36 grm. urea daily, so that it cannot be said that the average tissue waste is greater in the fevered individual on fever diet and at rest than in a healthy individual on mixed diet and taking an average amount of exercise. There is this difference, however, that in the healthy individual the nitrogenous waste, as represented in the urea thrown off, corresponds closely to the amount of nitrogenous food taken into the body, while that excreted in fever bears no relationship to the diet, and must therefore be formed from the tissues.

And when we come to inquire which tissues furnish it, the muscles must be regarded as standing pre-eminent. They undergo extreme wasting in fever. It is not generally held to be derived from the proteids of the liquor sanguinis, because this contains a large proportion of sodium salts, while the salts discharged in the urine of fever are poor in sodium.

It is likely that one other chief source of it is the blood-corpuscles. As yet hæmometric observations have not borne out the supposition that they actually decrease in number in fever. It is argued, however, that it is likely to be the case, from the fact that the urine contains much potassium salts,—salts which abound in the blood-corpuscles. Paton's observations (No. 661, iii. 1891, p. 209), as well as those of Pisenti (No. 104, xxi. 1886, p. 219), show that an attack of fever has the effect of suddenly diminishing the quantity of bile secreted. Paton remarks that it also becomes very pale or quite colourless, facts which do not certainly point to any increased destruction of blood-corpuscles.

The amount of **uric acid** thrown off is said to be also increased.

Senator was of opinion that there was no reason to suppose that there is increased formation of **carbonic acid** in fever. Sanderson, however (No. 193, xvi. 1876, p. 279), is compelled to accept it as a truth that more carbonic acid is produced than in health. There is certainly increased discharge, and this cannot be accounted for by excessive respiration. A healthy person on fever diet discharges about 22 grms. of CO_2 in an hour, and a person in fever about 32·3 grms. Part of this comes from the consumption in the body of materials which are not nitrogenous.

The **pigment in the urine** in the vast majority of cases is augmented, it is said, as much as twenty times. This might be employed as a basis for the argument that the blood-corpuscles are destroyed to excess.

The **discharge of water** is much increased in animals rendered artificially febrile, and chiefly in the commencement of the fever, a circumstance which in part accounts for the loss of weight. Fevered dogs lose from 3 to 4 per cent of their weight during the first twenty-four hours of fever; healthy dogs in a corresponding period of pure inanition only about 1·6 per cent. The diminished weight is chiefly due to loss of water (Senator).

SOURCE OF THE HEAT IN FEVER.

1168. From what has been remarked of the evidence of increased metabolism in fever the source of the heat cannot be far to seek. It is to be traced to the increased oxidation of the proteid and non-nitrogenous tissues. Owing to their being thus utilised, these tissues waste and give rise to the characteristic inanition.

RESPIRATORY AND CIRCULATORY PHENOMENA OF FEVER.

1169. The respirations are increased in frequency, owing, it is alleged, to the heated blood acting on the respiratory centre.

The heart beats more quickly in fever than in health. The cause is generally held to be the action of the high temperature upon it. Brunton's experiments demonstrate that increased temperature quickens the heart's beat in the frog.

The researches of Wolff, Landois, and Riegel have shown that the vascular tension in fever is usually lowered, and that the degree of relaxation proceeds hand in hand with the height of the temperature. The wonted tension returns with the decline of the temperature. In some cases, however, the tension may be unusually high.

The action of the heart muscle is evidently impaired. One explanation which has been given of this is that it suffers from cloudy swelling due to precipitation of its myosin.

CAUSE OF DEATH IN FEVER.

1170. The mere elevation of temperature in ordinary fevers is held by many to be insufficient of itself to account for death, for animals can be kept for days, or even weeks, alive where the rectal temperature is equivalent to 106° F. It requires a much higher temperature to prove fatal to them. In relapsing fever the temperature may come up to 107° F., and remain so for five or six days. And yet the mortality in this disease is small.

RISE OF TEMPERATURE AFTER DEATH.

1171. In some diseases such as **tetanus** the temperature rises several degrees after death. The causes seem to be that the chemical interchanges of the body continue after death, and that less heat is radiated from the surface. In the coagulation of myosin which takes place with the advent of rigor mortis, heat is apparently evolved. It is in cases such as tetanus, where the temperature at the time of death is high, that the increase after death is chiefly noticeable.

FEVER A SALUTARY PROCESS.

1172. It is sometimes said that fever heat subserves a salutary purpose, that it is one of nature's methods of destroying parasitical microbes. The temperature, it is alleged, runs so high that it destroys them. Against this is to be reckoned the fact that the exanthemata run a definite course whatever the temperature may be. The subject of contagious febrile diseases usually dies before the germs in his blood or tissues.

CHARACTER OF THE TEMPERATURE IN DIFFERENT FEBRILE CONDITIONS.

1173. **Measles.**—The temperature rises rapidly, so that by the evening of the second day it may reach 102° F. or more. With the appearance of the eruption (third to eighth day) a rapid accession going up to 104° to 105° F. probably on the sixth day. May remain constant for a day and falls suddenly.

Scarlatina.—Reaches to 104° to 105° F. during first day, or at any rate when the eruption is fully developed. It may rise occasionally to 110° or 112° F. later on. The temperature is higher in scarlet fever than in any other fever of the same class. Subsides slowly after the rash has reached its acme.

Typhoid.—Rises with an alternating character. From morning to evening an ascent of about 2° to 3° F., from evening to morning a fall of about 1° F. Result is that each evening there is an advance of about 1° to 2° on that previous. The point ultimately reached is from 103·5° to 104° F. or more. The mode of ascent is distinctive.

Typhus.—Ascent steady and continuous up to the fourth or fifth evening without morning remission. Maximum rarely under 104·9°

to 105° F., often reaching 107°, or even above this. Slight remission on sixth morning, and well-marked fall on seventh day, unless case very severe. After this a rise again, but rarely to former maximum. May fall in twelve to forty-eight hours to normal at period of defervescence on the thirteenth to seventeenth day. In fatal cases a rapid rise or fall. May go up in such to 108° or 109°.

Variola.—Rises rapidly during stage of invasion to 104° or 106·5° F. Falls during early period of eruption, and rises again at period of maturation to 102° to 104°, and when fatal issue threatens, even to 107°.

Relapsing Fever.—Continuous ascent for four or five days without evident morning remission. Finally reaches from 104° to 108° F. May afterwards remain stationary until crisis, when it becomes subnormal. At relapse rises suddenly again, even to a higher point than on first attack.

Erysipelas.—Ascends rapidly at outset—104°-105° F. on first evening. Maximum usually on third day, but may go on increasing as long as inflammation lasts, and attain to 106° to 108°. As a rule, distinct evening exacerbations.

Tubercular Phthisis of Lung.—Minimum temperature may be normal in the day, but is usually higher than normal. The maximum temperature may reach from 101° to 105° F.

Tubercular Meningitis.—Temperature irregular but above normal. Does not often rise above 101° to 102° F.

Influenza.—Rises often suddenly to 103° to 105° F. and declines slowly.

Literature on Fever.—**Ansiaux** (Influence of Ext. Temperature on Heat of Warm-Blooded Animals): Univ. of Liège, Inst. de physiol., Trav. du lab. de Léon Fredericq., iii. 1890, p. 169. **Bäumler** (Arteries of Skin in): Centralbl. f. d. med. Wissensch., xi. 1873, p. 179. **Berns** (Ludwig's Stromuhr and Fever Theory of Hüter): Centralbl. f. d. med. Wissensch., xiv. 1876, p. 598; *also*, Arch. f. path. Anat., lxix. 1877, p. 153. **Berthelot** (Animal Heat): Ann. de chim. et phys., xx. 1890, p. 177. **Boekmann** (Changes in Blood-Corpuscles): Deut. Arch. f. klin. Med., xxxi. 1881, p. 481. **Bouchard** (Doctrines of Fever): Med. Week, 1893, i. pp. 193, 217. **Burkart**: Deut. med. Wochnschr., v. 1879, p. 350 *et seq.* **Carter** (Heat Production and Dissipation in Normal and Febrile States): Journ. Nerv. and Ment. Dis., xvii. 1890, p. 782. **Charrin** (Thermic Elevations of Cellular Origin): Arch. de physiol. norm. et path., i. 1889, p. 683. **Colasanti**: Arch. f. d. ges. Physiol., xiv. 1876-77, p. 92. **Doyon** (Action of Encephalon on Temperature): Province méd., vi. 1892, p. 222. **v. Dubczcanski and Naunyn**: Arch. f. exper. Path. u. Pharmakol., i. 1873, p. 181. **Dubois** (Influence of Nervous System in Calorification): Compt. rend. Soc. de biol., v. 1893, pp. 156, 182. **Fick** (Development of Heat): Arch. f. d. ges. Physiol., li. 1891-92, p. 541. **Filehne**: Arch. f. path. Anat., cxxxi. 1893, p. 1. **Finkler** (Tissue Metabolism in): Arch. f. d. ges. Physiol., xxvii. 1881-82, p. 267. **Gad and Heymans** (Action of Temperature on Muscle): Arch. f. Physiol., 1890, Suppl. Bd., p. 59. **Geppert** (Gases of Arterial Blood in): Ztschr. f. klin. Med., ii. 1880-81, p. 355. **Goodridge**: Brit. Med. Journ., 1876, ii. p. 137; *Ibid.*, 1878, ii. p. 200; *also*, Practitioner, xxxiii. 1884, p. 1. **Hale-White** (Neurotic Theory of Pyrexia): Practitioner, xxxvi. 1886, p. 1; *also* (Theory of Pyrexia), Am. Journ. Med. Sc., 1890, p. 467. **Hale-White and Washbourn** (Temp. after Destruction of Cortex Cerebri): Journ. Physiol., xii. 1891, p. 271. **Hankin and Kanthack** (Fever produced by Injection of Sterile Cultures of Vibrio Metchnikovi): Proc. Camb. Philosoph. Soc., 1892, March, p. 311. **Jaquet**

(Oxidation in the Tissues): Arch. f. exp. Path. u. Pharmakol., xxix. 1891-92, p. 386. **Lassar** (Fever of Cold-Blooded Animals): Arch. f. d. ges. Physiol., x. 1875, p. 633. **Leyden**: Untersuchungen über das Fieber; Deut. Arch. f. klin. Med., v. p. 273. **Leyden and Fraenkel** (Expiration of Gases in): Arch. f. path. Anat., lxxvi. 1879, p. 136. **Liebermeister**: Handbuch d. Path. u. Therap. des Fiebers, 1875. **Loewy** (Tissue Metabolism in): Arch. f. path. Anat., cxxvi. 1891, p. 218. **Loomis**: N. Y. Med. Rec., xi. 1876, p. 615 *et seq.*; *Ibid.*, xii. 1877, p. 1. **Manassein** (Chemistry of Fever): Centralbl. f. d. med. Wissensch., ix. 1871, p. 852; (Gastric Juice in) Arch. f. path. Anat., lv. 1872, p. 413; (Extract of Muscles) *Ibid.*, lvi. 1872-73, p. 220. **Moore**: Text-book of the Continued and Eruptive Fevers, 1892. **Moxon**: Lancet, 1882, ii. p. 931. **Naunyn** (Urea Excretion and F.): Berl. klin. Wochnschr., vi. 1869, p. 42; *also*, Arch. f. Anat. Physiol. u. wissensch. Med., 1870, p. 159. **Ott** (Human Calorimetry): N. Y. Med. Journ., 1889, i. p. 29. **Pflüger**: Arch. f. d. ges. Physiol., xiv. 1876-77, p. 450; *Ibid.*, p. 469. **Richet**: Physiologie; travaux du laboratoire. V. I. Système nerveux; chaleur animale, 1893. **Riegel** (Heart's Contraction, Tension of Vessels in): Berl. klin. Wochnschr., xvii. 1880, p. 493. **Rosenthal** (Calorimetric Researches): Arch. f. Physiol., 1889, p. 1; *also* (Production of Heat in Mammalia), Berl. klin. Wochnschr., xxviii. 1891, p. 529; *Ibid.*, p. 670; *also* (Production of Heat in Fever), Internat. Beitr. z. wissensch. Med. Festschr. R. Virchow, 1891, i. p. 411. **Sanderson**: Privy Council Reps., 1875-76; *also*, Reprint, Practitioner, xvi. 1876, p. 257 *et seq.* **Schenck** (Temperature and Action of Muscle): Arch. f. d. ges. Physiol., lii. 1892, p. 456. **Senator**: Centralbl. f. d. med. Wissensch., vi. 1868, p. 708; *Ibid.*, ix. 1871, pp. 737, 753; *Ibid.*, xi. 1873, p. 84; *also*, Arch. f. d. ges. Physiol., xiv. 1876, p. 448; *Ibid.*, xiv. 1877, p. 492; *also*, Untersuch. üb. d. fieberhaften Process, 1873. **Sigalas**: Recherches expér. de calorimétrie animale, 1890. **Stevens**: Lancet, 1893, ii. p. 492. **Stewart** (Heat Production): Journ. Physiol., xii. 1891, p. 409. **Stolnikoff** (Function of Pancreas in): Arch. f. path. Anat., xc. 1882, p. 389. **Traube**: Ges. Beitr. z. Path. u. Physiol., 1871, ii. pt. 1, p. 624, pt. 2, p. 679; 1878, iii. pp. 503, 581, 611. **Ughetti**: La febbre, 1893. **Unruh**: Arch. f. path. Anat., xlviii. 1869, p. 227. **Winternitz**: Deut. Med.-Ztg., xi. 1890, p. 415. **Wood**: Fever, a Study in Morbid and Normal Physiology, 1880. **Wunderlich**: Arch. f. physiol. Heilk., i. 1842, p. 266 *et seq.* **Zuntz** (Tissue Metabolism in): Arch. f. Physiol., 1882, p. 115; *also*, Centralbl. f. d. med. Wissensch., xx. 1882, p. 561.

KEY TO REFERENCES IN TEXT

NO.
1. Post-mortem Examinations. Virchow (Eng. Transl. by Smith).
2. Ueb. d. Verand. d. willkür. Muskeln im Typhus abdom. Zenker, 1864.
3. Recherches sur les lésions du centre ovale des hemisphères cérébraux étudiés au point de vue des localizations cérébrales. Pitres, 1877.
4. Archives de Physiol.
5. Journ. of Anat. and Physiol.
6. British Med. Journ.
7. How to work with the microscope. Beale, 5th ed.
8. The microscope and microscopic technology (Eng. Transl. by Cutter), Frey.
9. Quart. Journ. Microscop. Sc.
10. Mikroscop. Technik. Friedländer, 1886.
11. Fortschr. d. Med.
12. Sitzungsb. d. k. k. Akad., Wien.
13. Arch. f. path. Anat.
14. Arch. f. mik. Anat.
15. Pract. Histol. and Path. Gibbes, 1885.
16. Handbook for the Physiol. Laboratory. Brunton, Foster, Klein, and Sanderson.
17. Trans. Microscop. Soc.
18. Traité technique d'Histol. Ranvier.
19. Edin. Med. Journ.
20. Ann. d. Chem. u. Pharm.
21. Text-book of Physiol. Chem. Gamgee, 1880.
22. Charité Annalen.
23. Lectures on Surg. Path. Paget, ed. by Turner.
24. On certain effects of starvation on vegetable and animal tissues. Cunningham, 1879.
25. Traité d'anat. path. Lancereaux, 1879.
26. Communicazione alla Reale Academia di Medicina di Torino.
27. The Chemistry of the coal-tar colours (Eng. Transl. by Knecht). Benedikt, 1886.
28. West Riding Asylum Reports.
29. Manual of Brain Examination. Lewis.
30. Handb. d. Chem. Analyse. Hoppe-Seyler.
31. Vorlesungen üb. allgem. Pathol. Cohnheim.
32. Text-book of Physiol. M'Kendrick, 1888.
33. Surg. Pathology. N. Syd. Soc. Billroth.

NO.

34. Med. Chir. Trans.
35. Die krankhaften Geschwülste. Virchow.
36. Canstatt's Jahresbericht.
37. Der epithelial Krebs. Thiersch, 1865.
38. Diseases of the Chest. Laennec, 1834.
39. Recherches sur la Phthisie. Bayle.
40. Comptes rendus d. l'Acad. d. Sc.
41. Report to Med. Officer Privy Council.
42. Die Tuberculose v. Standpunkte d. Infectionslehre. Cohnheim, 1880.
43. Berl. klin. Wochnschr.
44. Mittheil. a. d. k. Gesundheitsamte.
45. Société impér. de Méd. de Vienne.
46. Wien. med. Jahrbücher.
47. Wien. Gaz. d. Aerzte.
48. Zeitschr. f. wiss. Mikr. u. mikr. Technik.
49. Virchow and Hirsch's Jahresbericht.
50. Centralbl. f. d. med. Wissensch.
51. Arch. f. Anat. u. Physiol. (Dubois-Reymond's).
52. A System of Surgery. Holmes.
53. The Physiol. and Pathol. of the Blood. Norris, 1882.
54. Wien. med. Presse.
55. Arch. f. Dermatol. u. Syphilid.
56. Deut. Ztschr. f. klin. Med.
57. Gaz. med. italiana lombardica.
58. Provincial Med. Trans.
59. The Lancet.
60. Neue Untersuchungen üb. d. Entzündung. Cohnheim, 1873.
61. Philosoph. Magazine.
62. Exper. and Pract. Researches on Inflammation. Addison.
63. Guy's Hosp. Rep.
64. Muller's Arch.
65. Philos. Trans.
66. Rollet's Untersuchungen.
67. Medicin. Zeitung d. Vereins f. Heilkunde im Preussen.
68. Handbuch d. spec. Path. u. Therap. Virchow.
69. Cellular Path. Virchow.
70. Stricker's Studien.
71. De l'Inflammation et de la Circulation. Schiff, 1873.
72. The Physiol. Anat. and Physiol. of Man. Todd and Bowman.
73. Sitzungsb. d. k. sächsischen Gesellschaft d. Wissensch.
74. Beitrage z. norm. u. path. Histol. d. Hornhaut. His., 1856.
75. Manual of Histology (Eng. Transl.). N. Syd. Soc. Stricker.
76. Reichert and Dubois-Reymond's Arch.
77. Gottinger Nachrichten.
78. Physiol. of the Circulation. Pettigrew, 1874.
79. On anormal nutrition in articular cartilages. Redfern, 1849.
80. De invloed d. Zenuwen op de Onsteking. Snellen, 1857.
81. Deut. chirurg. Handb. d. allg. Path. d. Kreislaufs u. d. Ernährung.
82. Americ. Journ. Med. Sc.
83. Das Chinin als Antiphlogisticum. Diss. Bern, Scharrenbroich, 1867.
84. Das Chinin als Antiphlogisticum. Diss. Giessen, Martin, 1868.
85. Arb. a. d. berner path. Inst. Wurzburg.

NO.

86. Zellsubstanz, Kern, u. Zelltheilung. Flemming, 1882.
87. Schriften d. naturw. Vereins f. Schlesw.-Holstein.
88. Atlas of Histology. Klein and Noble Smith, 1880.
89. Zellbildung u. Zelltheilung. Strasburger, 1880.
90. Coccobacteria septica. Billroth.
91. Ztschr. f. klin. Med.
92. Arch. f. klin. Chirurg.
93. Deut. med. Wochnschr.
94. Compt. rend. de la soc. de Biol.
95. Rev. d. Chirurg.
96. Allg. Wien. med. Ztng.
97. Arb. a. d. Zöol. Institut. Wien.
98. Biolog. Centralbl.
99. Zool. Anzeiger.
100. Ztschr. f. wissensch. Zoolog.
101. Die Regeneration v. Geweben u. Organen b. d. Wirbelthieren. Fraise, 1885.
102. Text-book Path. Histol. N. Syd. Soc. Rindfleisch.
103. Path. of Bronchitis, etc. Hamilton.
104. Arch. f. exp. Path. u. Pharmakol.
105. Untersuch. üb. d. feineren Vorgänge b. d. Entzündung. Heller, 1869.
106. Soc. d. Chirurgie.
107. Arch. gén. d. méd.
108. Ueb. Transplant. v. Haaren. Schweninger, 1875.
109. Montpellier méd.
110. Untersuch. üb. path. Bindegewebs u. Gefäss-Neubildung. Ziegler, 1876.
111. Untersuch. üb. d. Entwickel. d. Blutgefässe. Billroth, 1856.
112. Month. mic. Journ.
113. Die Gewebsspannung in ihren Einflusse a. d. örtliche Blut u. Lymphbeeng ung. Landerer, 1884.
114. Volkmann's Sammlung klin. Vorträge.
115. Handbuch d. Chirurg. Pitha and Billroth.
116. Ueb. d. Verfettung fremder Körper in d. Bauchhöhle. Heidenhain, 1872.
117. Vierteljahrschr. f. Dermatol. u. Syphilid.
118. Lymphatic System. Klein.
119. Verhandlungen d. phys. med. Gesellsch. Würzburg.
120. Wucherungen d. Endothelien b. path. Neubildungen. Herrenkohl, 1873.
121. Exper. Untersuch. üb. d. Herkunft d. Tuberkel-elemente. Ziegler, 1876.
122. Handbuch d. spec. Path. u. Therap. v. Ziemssen.
123. Das tuberkelähnliche Lymphadenom. Wagner, 1871.
124. Die centrale Keratitis. Eberth, 1875.
125. Die normale Resorption d. Knochengewebes. Kölliker, 1873.
126. Arch. d. Heilkunde.
127. Treatise on the joints. Barwell.
128. Collected Works. John Hunter. Ed. by Palmer.
129. Gesammelte Abhandl. z. wissensch. Med. Virchow.
130. Deut. Ztschr. f. Chirurg.
131. Ueb. d. Senftlebenschen Versuch., etc. Burdach.
132. v. Langenbeck's Arch.
133. Arch. per le science med.
134. Schmidt's Jahrbüch.
135. Ueb. d. physiol. Heilungsprocess nach subcutan. Tenotomie d. Achillessehne. Dembowsky, 1868.

NO.

136. Sur le trajet et la distribution périphérique des nerfs régenérés. C. Vanlair.
137. Lond. Journ. of Med.
138. Arch. f. phys. Heilkunde.
139. Ztschr. f. rat. Med.
140. Deut. Arch. f. klin. Med.
141. Prager Ztschr. f. Heilk.
142. Ueb. örtliche Wärme-entwickelung in d. Entzündung. Laudien, 1869.
143. A treatise on the Blood, Inflammation, and Gunshot Wounds. John Hunter, 1794. Ed. by Home.
144. Physiol. d. Menschen. Donders, 1859.
145. Text-book of Physiol. Foster.
146. Prag. med. Wochnschr.
147. Annals of Surgery.
148. Brit. and For. Med.-Chir. Rev.
149. Proc. Royal Soc.
150. L'union méd.
151. Beiträge z. Kenntniss ub. d. Vorkommen d. Tuberkel-Bacillen in tuberkulosen Organen. Muhlert, 1885.
152. Untersuch. üb. Lymphdrüsen-Tuberculose. Schüppel, 1871.
153. Bull. d. l'Acad. d. Méd.
154. Arch. vétérinaires.
155. La phthisie pulm. Cornil et Herard, 1867.
156. Histol. u. exper. Studien üb. d. Tuberculose. Hering, 1873.
157. The artificial production of Tuberculosis in the lower animals. Wilson-Fox.
158. Kritische u. exper. Beiträge z. Lehre v. d. Futterungs-Tuberculose. Wesener, 1885.
159. Dorpat. med. Ztschr.
160. Deut. Ztschr. f. Thiermed.
161. Rep. Local Gov. Board. Suppl. by Med. Off.
162. Munch. ärztl. Intelligenzblatt.
163. Baier ärztl. Intelligenzblatt.
164. Elements of Physiol. and Path. Chem. Charles, 1884.
165. Des tubercles de la mamelle. Thèse, Paris, Dubar. 1881.
166. Le Progres méd.
167. Le tubercle du sein chez la femme et chez l'homme. Poirier, 1882.
168. Die Tuberculose. Waldenburg, 1869.
169. Arch. f. d. ges. Physiol. Pflüger.
170. Lehrbuch d. allg. Path. Perls.
171. Observations in Clinical Med. Begbie, 1862.
172. Die Störungen d. Lungenkreislaufs u. ihr. Einfluss a. d. Blutdruck. Lichtheim, 1876.
173. The Disorders of Digestion. Brunton, 1886.
174. Tractatus de corde. Lower, 1669-1680.
175. Sitzungsb. d. physik. medic. Societät z. Erlangen.
176. Notes on Filaria Disease. Customs Med. Rep. Manson.
177. The microscopic organisms found in the Blood of Man and Animals. Lewis, 1879.
178. Lond. Med. Gaz.
179. Journ. of Physiology.
180. Bresl. arztl. Ztschr.
181. Phila. Med. and Surg. Rep.
182. Étude sur les épanchements chyliformes des cavités séreuses. Perrée, 1882.

NO.
183. Characteristik d. epidem. Cholera. Schmidt, 1850.
184. Physiolog. Chemistry (Cavendish Soc.). Lehmann.
185. Med. Times and Gaz.
186. Elements of Human Physiology (Eng. Transl. by Gamgee). Hermann, 1875.
187. Ztschr. f. physiol. Chemie. Hoppe-Seyler.
188. Wiener med. Wochnschr.
189. Proc. Royal Soc. of Edinburgh.
190. Pogendorff's Annalen d. Physic u. Chemie.
191. Lungenentzündung, Tuberculose, u. Schwindsucht. Buhl, 1872.
192. Trans. Path. Soc. Lond.
193. The Practitioner.
194. Clinical demonstrations on ophthalmic subjects. Wolfe, 1884.
195. Régénération des os. Ollier.
196. Casuistische Mitth. a. d. path. anat. Institut z. Marburg. Cassel.
197. Researches in obstetrics. M. Duncan, 1868.
198. Discourses on the Nature and Cure of Wounds. 3rd edit. John Bell, 1812.
199. New York Med. Rec.
200. Journ. de l'anat. et de la physiol.
201. Experimentalstudien üb. d. Histol. d. Blutes. Rindfleisch, 1863.
202. Mik. Anat. Kölliker.
203. Dissertation, Halle. Aly.
204. Gaz. méd. de Paris.
205. De l'anémie, etc. Thèse agrég., 1880.
206. Cyclop. Pract. Med. (Eng. Transl.). v. Ziemssen.
207. Handbuch d. menschl. Anat. Krause, 1876.
208. Arch. f. klin. Med.
209. A Syst. of Med. Ed. by Reynolds.
210. Lehrbuch d. Krankheitslehre. 1844.
211. Manual of Gen. Path. (Eng. Transl.). Wagner.
212. Thèse de Paris. Dupérié, 1878.
213. Thèse de Paris. Cadet, 1881.
214. Chimie pathol. Quinquad, 1880.
215. Würtemburg Correspondenzblatt.
216. Edin. Clin. and Path. Journ.
217. Dissert. Dorpat, Nauck, 1886.
218. Recherches sur l'anat. norm. et path. du sang. Hayem, 1878.
219. Wien. med. Ztng.
220. Cause of the Coagulation of the Blood. Richardson, 1858.
221. Viertaljahrschr. f. d. prakt. Heilkunde.
222. Bibl. univ. de Genève, 1821.
223. Handbuch d. Physiol. Müller, 1844.
224. Leçons sur le sang et les alterations de ce liquide. Magendie, 1838.
225. Untersuch. z. Naturlehre d. Menschen. Martels and Moleschott.
226. Journ. de la Physiol.
227. Berichte d. deut. chem. Gesellsch. z. Berlin.
228. Ztschr. f. Biol.
229. Wien. Med. Blätter.
230. Hewson's Collected Works. Ed. by Gulliver. Syd. Soc., 1846.
231. Animal Chemistry (Eng. Transl.). Syd. Soc., Simon, 1845.
232. Bull. de l'Acad. Roy. de Méd. de Belgique.
233. Die progressive perniciöse Anæmie. Eichorst, 1878.
234. Univ. méd. Paris.

NO.
235. Manual of Mic. Anat. (Eng. Transl.). Kölliker, 1860.
236. Ueb. d. Chlorose u. d. damit zusammenhängenden Anomalien im Gefässapparate. Virchow, 1872.
237. Lo sperimentale.
238. Tageblatt d. 42 Versammlung deutsch. Naturforschr. u. Aerzte in Dresden.
239. Correspondenzbl. f. schweizerische Aerzte.
240. Movimento med.-chir.
241. Proceed. Roy. Institution Gt. Britain.
242. Handbuch d. spec. Path. u. Therap. Eichorst, 1885.
243. Revue mensuelle de méd.
244. Bull. de la Soc. Anat.
245. Froriep's Notizen.
246. Beobachtungen u. Versuche üb. d. Ausscheid. d. Harnsäure, Ranke, 1858.
247. Organic Chemistry, 12th ed. Fownes.
248. Jenaische Zeitschr. f. Med.
249. Nouv. Dict. de Méd. et de Chirurg.
250. Glasg. Med. Journ.
251. Gaz. hebdom.
252. Liebig's Annalen.
253. Dissert. Erlangen. Toenniessen, 1881.
254. Leucocythæmia or white-cell Blood in relation to the Physiol. and Path. of the Lymph. Glandular Syst. Bennett, 1852.
255. Manual of Path. Histol. (Eng. Transl.). Cornil et Ranvier, 1882.
256. Lehrbuch d. path. Gewebelehre. Rindfleisch.
257. Rev. scientifique.
258. Ueb. d. Diabetes. Frerichs, 1884.
259. Leçons de Physiol. Cl. Bernard, 1855.
260. Balneotherapie. 3 Aufl. Braun, 1868.
261. Untersuch. üb. Zuckerbildung. Schiff, 1859.
262. Lectures on some of the applications of Chemistry and Mechanics to Path. and Therapeutics. Bence Jones, 1867.
263. Physiol. Chemie. Lehmann.
264. Trans. Internat. Med. Cong. London, 1881.
265. On Granular Degeneration of the Kidneys. Christison, 1839.
266. De l'Urémie. Feltz and Ritter, 1881.
267. Revue médicale de l'Est.
268. Die Bright'sche Nierenkrankheit u. d. Behandlung. Frerichs.
269. Gaz. chim. ital.
270. On Rheumatism, Rheumatic Gout, and Sciatica. Fuller, 1860.
271. On the Action of Medicines. Headland.
272. On Rheumatism. Todd.
273. Rheumatism ; its nature ; its pathology ; and its successful treatment. Maclagan.
274. Klinik d. Gelenkkrankheiten. Hueter, 1871.
275. A Treatise on Gout and Rheumatic Gout. Garrod, 1876.
276. On the Formation of Uric Acid in Animals. Latham, 1884.
277. Magendie's Journal de Physiol.
278. Essai d'hematologie pathologique. Andral.
279. Chimie pathologique. Becquerel and Rodier.
280. Month. Journ. Med. Sc.
281. Diseases of the Lungs and Heart. Walshe, 1854.
282. Die Selbsstandigkeit d. sympath. Nervensystems. Bidder and Volkmann, 1842.

NO.
283. Berichte d. sächsischen Akad.
284. Maladies du Cœur. Ger. Sée, 1883.
285. Proc. Physiol. Soc.
286. Ludwig's Arbeiten.
287. Illustrations of the Influence of the Mind upon the Body. Hack Tuke, 1872.
288. Diseases of the Heart and Aorta. Hayden, 1875.
289. Diseases of the Heart and Aorta. Balfour, 1876.
290. Diseases of the Heart and Aorta. Stokes, 1854.
291. Commentarii de morborum historia et curatione. Heberden, 1807.
292. Medical Transactions.
293. Trans. Clin. Soc. Lond.
294. Trans. Roy. Soc. Edin.
295. Valvular Disease of the Heart. Sansom, 1886.
296. Materia Medica and Therapeutics. Vegetable Kingdom. Phillips, 1886.
297. Amer. Journ. Med. Sc.
298. Nordiskt med. Arkiv.
299. Mikroorganismen b. d. Wundinfectionskrank. d. Menschen. Rosenbach, 1884.
300. L'Abeille médicale.
301. Text-book of Path. Histology.
302. Les Bacteries et leur rôle dans l'anatomie et l'histologie pathol. des maladies infect. Cornil et Babes.
303. Gior. veneto di sc. med.
304. Dissertation. Zurich, Hepp, 1853.
305. Memoir on Ganglia and Nerves of the Heart. Lee, 1851.
306. Text-book of Pract. Med. (Eng. Transl.). Niemeyer, 1884.
307. Ueb. d. Zusammenhang v. Herz- u. Nierenkrankheiten, 1856.
308. Lectures on Bright's Disease. Johnson, 1873.
309. On the connection of Bright's Disease with changes in the Vascular System. Galabin, 1873.
310. Bright's Diseases of the Kidney. Stewart, 1871.
311. The Bearings of Chronic Disease of the Heart on Pregnancy, etc. Macdonald, 1878.
312. Annales de Chimie et de Physique.
313. Des Causes et du Mechanisme du Bruit de Soufflet. Bergeon, 1868.
314. Internat. Journ. of Med. Sc.
315. Clinical Med. Gairdner.
316. Gesammelte Beiträge zur Path. u. Physiol. Traube, 1871.
317. Ned. Lancet.
318. The Collected Works of Dr. P. Latham. N. Syd. Soc., 1876.
319. Trans. Edin. Med.-Chir. Soc.
320. Diseases of the Heart. Flint, 1870.
321. Text-book of Human Physiology (Eng. Transl. by Stirling). Landois, 1885.
322. Valvular Disease of the Heart. Peacock, 1865.
323. Die trophischen Beziehungen d. Nervi Vagi z. Herzmuskel. Eichorst, 1879.
324. Die Fett-Metamorphose d. Herzfleisches. Wagner, 1864.
325. Gaz. des hôp.
326. Des complications cardiaques du croup et de la diphtherie. Labadie-Lagrave, 1873.
327. Die luetische Erkrankung der Hirnarterien. Heubner, 1874.
328. Lehrbuch d. spec. path. Anat. Orth, 1887.
329. Atlas d'Anatomie path. (Eng. Transl. by Greenfield). Lancereaux, 1880.

NO.
330. Traité de Path. interne. Jaccoud, 1877.
331. Clinical Lectures on Senile and Chronic Diseases. N. Syd. Soc. Charcot, 1881.
332. Anatomie path. Cruveilhier.
333. Recherches sur quelques points de la pathogénie d. hémorrhagies cérébrales. Bouchard, 1866 (Eng. Transl., same, 1872).
334. Ueb. hyaline Thrombenbildung, etc. Obermüller, 1886.
335. Traité d'auscultation. Laennec.
336. Untersuch. üb. d. hæmorrhagischen Infarct. ·Litten, 1879.
337. Text-book of Path. Anat. (Eng. Transl. by Macalister). Ziegler, 1883.
338. Untersuch. üb. d. embolischen Processe. Cohnheim, 1872.
339. Beitrag z. norm. u. path. Structur d. Lungen. Zenker.
340. Travaux du Laboratoire. Marey.
341. Medical Dictionary. Hooper, 1848.
342. Dictionary of Pract. Med. Copland.
343. Handbook of the Sphygmograph. Sanderson.
344. La méthode graphique dans les sciences expérimentales. Marey, 1878.
345. The Sphygmograph. Dudgeon, 1882.
346. La circulation du sang à l'état physiol. et dans les maladies. Marey, 1881.
347. Principles of Human Physiol. Carpenter and Power, 1881.
348. Die Lehre v. Arterienpuls. Landois, 1872.
349. Students' Guide to the Examination of the Pulse. Bramwell, 1883.
350. The Science and Practice of Surgery. Gant, 1886.
351. Nature and Treatment of Stomach and Renal Diseases. Prout, 1843.
352. Gazetta lekarska.
353. Rev. de méd.
354. Bull. de la Soc. chimique de Paris.
355. Beiträge z. Biol. d. Pflanzen.
356. Untersuch. üb. niedere Pilze. Nägeli, 1882.
357. Ueb. d. Zersetzung d. Gelatine u. d. Eiweisses. Nencki, 1876.
358. Ueb. Ptomaïne, 1885; Weitere Untersuch. üb. Ptomaine. Brieger, 1885.
359. Die Mikroorganismen. Flügge, 1886.
360. Die Grundriss d. Bakterienkunde. Fraenkel, 1887.
361. Rep. of the British Association.
362. Journ. of the Roy. Agricultural Soc.
363. Die Bakterien-Forschung. Hueppe, 1886.
364. The Antiseptic System. Sansom.
365. Les organismes vivants de l'atmosphere. Miquel, 1883.
366. Ztschr. f. Hygiene.
367. Archives d. sciences physiques naturelles.
368. Clin. Soc. Trans., Lond.
369. Opera omnia. Syd. Soc., Sydenham, 1746.
370. Handbook of Path. Anat. Delafield and Prudden, 1885.
371. An investigation into the pathology of pernicious anæmia. Hunter, 1888.
372. Researches on the Spinal Cord. B. Séquard, 1855.
373. Lehrbuch d. Physiol. d. Menschen. Schiff, 1858-59.
374. Handworterbuch d. Physiol. Wagner.
375. Œuvres de Legallois, 1830.
376. Die Athembewegungen. Rosenthal, 1862.
377. The Movements of Respiration. Marckwald.
378. Recherches sur le système nerveux. Flourens, $1^{\text{ère}}$ éd., 1824.
379. Traité de physiol. 3^{me} éd., 1869.

NO.
380. Heidenhain's Studien.
381. Würzburger Verhandlungen.
382. Diseases of the Lungs and Pleuræ. Douglas Powell, 1886.
383. Sur le rôle de l'élasticité du poumon dans les phénomènes de la circulation. D'Arsonval, 1877.
384. Leçons sur la respiration. Paul Bert, 1870.
385. Précis de percussion et d'auscultation. P. Niemeyer (French Transl. by Szerlecki), 1874.
386. Researches on Phthisis. Louis (Eng. Transl. by Walshe), 1846.
387. Diseases of the Chest and Mediate Auscultation. Laennec (Eng. Transl. by Forbes), 1838.
388. La phthisie pulmonaire. Herard, Cornil, and Hanot, 1888.
389. Giornale internaz. de. science med.
390. Bull. dell' acad. med. di Roma.
391. Annali univers. di medic. Luglio.
392. Phila. Med. News.
393. Arch. ital. d. Laryng.
394. Lyon méd.
395. De l'œdème de la paroi thoracique dans les pleurésies non purulente. Thèse de Paris, 1885.
396. Experimental Researches. Bennet-Dowler, 1845-51.
397. Diseases of the Lungs from Mechanical Causes. Holland, 1843.
398. Krankheiten d. Arbeiter.
399. Boston Med. and Surg. Journ.
400. Pneumo-dynamics. Garland, 1878.
401. Dublin Hosp. Rep.
402. Untersuchungen üb. Staubinhalation u. Staubmetastase. Arnold, 1885.
403. Dublin. Med. Journ.
404. Cyclopædia of Anat. and Physiol. Todd, 1852.
405. Diagnosis and Treatment of Diseases of the Chest. Stokes, 1857.
406. Sputum. Troup, 1886.
407. Collective Investigation Record. Brit. Med. Assoc., July 1883.
408. Pulmonary Phthisis. James, 1888.
409. Klinische Vorträge üb. d. Lungenschwindsucht. Niemeyer, 1867.
410. Diseases of the Chest. Fuller, 1862.
411. Der Mechanismus d. Respirat. u. Circulat. Mendelssohn, 1845.
412. Abhandl. üb. Emphysem. Fuchs, 1845.
413. Anatomy of the Human Body. John Bell, 1797.
414. Manual of Path. Anat. Rokitansky (Eng. Transl., N. Syd. Soc., by Swaine), 1854.
415. Monthly Med. Journ., Edin.
416. Manual of Path. Histol. Rindfleisch (Eng. Transl., N. Syd. Soc., by Baxter), 1872.
417. Lehrbuch d. path. Anat. Birch-Hirschfeld, 1877.
418. Das Sauerstoffbedürfniss d. Organismus. Ehrlich, 1885.
419. Artificial Respiration in Still-born Children. Champneys, 1887.
420. Manual of Percussion and Auscultation. Flint, 1876.
421. Archives de neurologie.
422. Observations on Diphtheria. Wade.
423. Annales de l'Institut Pasteur.
424. Dissertation historique sur l'espèce de mal de gorge gangréneux, etc. Chomel, 1749.

NO.
425. An account of the sore throat attended with ulcers. Fothergill, 1754.
426. Trans. Amer. Phil. Soc.
427. Des inflammations spéciales du tissu muqueux et en particulier de la diphthérite. Bretonneau, 1826.
428. Inquiry into the Nature, Cause, and Cure of the Croup. Home, 1765.
429. Die Pathogenese d. epidem. Diphtherie. Oertel, 1887.
430. Exper. Untersuch. üb. Diphtherie. Oertel, 1871.
431. Ueb. d. Resorption durch d. Lungen. Königsberg. Dissert., 1879.
432. Manual of Diseases of the Throat and Nose. Mackenzie, 1884.
433. Diseases of Throat and Windpipe. Gibb, 1864.
434. Diseases of the Larynx. Gottstein (Eng. Transl. by M'Bride).
435. Vorlesungen üb. d. Krankheiten d. Kehlkopfes, etc. Schrötter.
436. An Essay on Asphyxia. Johnson, 1889.
437. St. Barthol. Hosp. Rep.
438. Jaundice: its Pathology and Treatment. Harley, 1863.
439. Arbeiten a. d. path. Inst. zu München.
440. Ueb. Epithelwucherung u. Krebs. Friedländer, 1877.
441. Atlas et traité d'anat. path. Lancereaux.
442. Handbuch d. Physiol. Hermann.
443. Diseases of the Liver. Harley.
444. Du suc gastrique chez l'homme et les animaux, 1878.
445. Journ. of Comp. Path. and Therapeut.
446. La glande bilaire. Sabourin, 1888.
447. La digestion stomacale. Herzen, 1886.
448. Du suc gastrique. Richet, 1878.
449. Leçons sur la digestion. Schiff, 1867.
450. The Gastric Juice and the Physiol. of Digestion. Beaumont, 1838.
451. Die Lehre v. d. Verdauung. Ewald, 1879.
452. Respiratory Functions of the Nose. Macdonald, 1889.
453. The Tongue as an Indication of Disease. Dickinson, 1888.
454. The digestive Ferments. Roberts, 1880.
455. Leçons sur les phénomènes de la vie. C. Bernard, 1879.
456. Lectures on Dietetics and Dyspepsia. Roberts, 1886.
457. Atrophy of the Stomach. Fenwick, 1880.
458. Diseases of the Stomach. Fenwick, 1880.
459. Leçons orales. Dupuytren, Brussels ed.
460. Diseases of Stomach. Brinton, 1859.
461. Intestinal Obstruction. Brinton, 1867.
462. Diseases of the Liver. Murchison, 1885.
463. Maladies du foie. Cyr, 1887.
464. The Bile, Jaundice, and Bilious Diseases. W. Legg, 1880.
465. Text-book of Physiology. M'Kendrick, 1888-89.
466. Bright's Diseases of the Kidneys. Stewart, 1871.
467. Maladies du foie et des reins. Charcot, 1877.
468. Diseases of the Kidneys. Ralfe, 1885.
469. Clinical Cases. Bright, 1827.
470. Clinical Lectures on Important Symptoms. Stewart, 1888.
471. Albuminuria in Health and Disease. Senator (Eng. Transl., N. Syd. Soc.), 1884.
472. Die Harncylinder. Burkart, 1874.
473. Bedside Urine-testing. Oliver, 1889.
474. Ueb. d. Zusammenhang v. Herz u. Nierenkrankheiten. Traube, 1856.
475. Handbuch d. Physiol. Hermann.

NO.
476. Arch. f. Hygiene.
477. Introduction to Human Anatomy. Turner, 1877.
478. Discussion on Albuminuria at Glasgow Path. and Clin. Soc., 1884.
479. Works of the late J. W. Begbie. New Syd. Soc.
480. Lectures on Bright's Disease. Saundby, 1889.
481. Lond. Hosp. Rep.
482. Beiträge z. Chemie d. Eiweissharns, 1873.
483. Bright's Disease. Purdy, 1886.
484. Practical Treatise on Diseases of the Kidneys. Ralfe, 1885.
485. Urinary Diseases. Wilks.
486. Die Lehre vom Harn. Salkowski and Leube, 1882.
487. Text-book of Physiology. M'Kendrick, 1885.
488. Zeitschr. f. Chemie.
489. Lehrbuch d. phys. u. path. Chemie. Bunge, 1889.
490. Treatise on Gout and Rheumatic Gout. Garrod, 1876.
491. Handbuch d. path. Anat. Klebs, 1868.
492. Beitr. z. path. Anat. u. allg. Path. Nauwerck and Ziegler.
493. Trans. Obstetrical Soc. Lond.
494. Arch. f. Gynækol.
495. Trans. Obstetrical Soc. Lond.
496. Diseases of Women. Tait, 1877.
497. Clinical Lectures on Diseases of Women. Matthews-Duncan, 1883.
498. Displacements of the Uterus. Schultze (Eng. Transl. by Macan), 1888.
499. Perimetritis and Parametritis. J. M. Duncan, 1869.
500. Zeitschr. f. Heilkunde.
501. Ectopic Pregnancy and Pelvic Hæmatocele. Tait, 1888.
502. Eierstock u. Ei. Waldeyer, 1870.
503. Collected Works of F. M. Balfour.
504. Archives de Méd.
505. De la tuberculose des organes génitaux de la femme. Brouardel, 1865.
506. De la tuberculose génitale. Daurios, 1889.
507. Deutsche Klinik.
508. Boston Med. and Surg. Journal.
509. Diseases of the Testis. Curling.
510. Constitutional and Local Effects of Disease of the Supra-renal Capsules. Addison, 1855.
511. Lond. Med. Rec.
512. Henle's "Anatomie."
513. Clinical Med., Graves, Syd. Soc.
514. Casper's Wochenschrift.
515. Text-book of Midwifery. Spiegelberg (Eng. Transl., N. Syd. Soc.), 1870.
516. Archives italiennes de Biologie.
517. Arch. f. Psychiat.
518. Arch. f. Ophthalmol.
519. Maladies de Paget. Wickham, 1890.
520. Leçons sur les-sporozoaires. Balbiani, 1884.
521. Brain.
522. Neurolog. Centralblatt.
523. Deut. Chirurg. Billroth and Lücke.
524. Leçons sur les localizations. Charcot, 1876-90.
525. Epilepsy and other Chronic Convulsive Diseases. Gowers, 1881.
526. Journal of Mental Science.

NO.

527. Die Seelenblindheit als Herderscheinung und ihre Beziehungen zur homonymen Hemianopsia, etc. Willbrand, 1887.
528. Archives de Neurologie.
529. Der Verlauf motorischen und sensiblen Bahnen durch das Lendenmark des Kaninchens. Ludwig and Woroschiloff, 1874.
530. Secondary Degeneration of Spinal Cord. Tooth, 1889.
531. Ueb. d. Function des Vierhügels. Extract from Vratsch, v. Monakow, 1883.
532. On Aphasia. Ross, 1887.
533. Traité d'encephalite. Bouillaud, 1825.
534. Contribution experim. à la path. et à l'anatom. path. de la moëlle épinière, 1885.
535. Klinik d. Ruckenmarkskrankheiten. Leyden, 1875.
536. Ueb. multiple inselförmige Sklerose d. Centralnervensystems im Kindesalter. Unger, 1887.
537. Zur Kentniss d. syph. Erkrank. d. centralen Nervensystems. Oppenheim, 1890.
538. Diseases of the Brain. Gowers, 1885.
539. Journ. of Mental Science.
540. Studien in d. Anat. d. Nervensystems u. d. Bindegewebes. Key and Retzius, 1875.
541. Ueb. Gehirndruck u. Gehirncompression. Adamkiewicz.
542. Études sur les traumatismes cérébraux. Duret, 1878.
543. Lectures on Localisation of Cerebral and Spinal Diseases. Charcot (Eng. Transl., N. Syd. Soc.), 1883.
544. Clinical Lectures on Mental Diseases. Clouston.
545. Sur la trépanation du crâne. Lucas-Championnière, 1878.
546. Untersuch. üb. d. Localisation d. Functionen in d. Grosshirnrinde des Menschen. Exner, 1880.
547. Ueb. d. Functionen d. Grosshirnrinde. Munk.
548. The Functions of the Brain. Ferrier, 1886.
549. Traité complet de l'anatomie, de la physiologie, et de la pathologie du système nerveux cérébro-spinal (Atlas). Foville.
550. Die aphasische Symptomen-Complex. Wernicke, 1874.
551. Sulle Funzioni del Cervello. Secunda communicazione; Centri Psico-sensori corticali. Luciani and Tamburini, 1879.
552. Gesammelte Mittheilungen. Munk, 1881.
553. Archives of Ophthalmology and Otology.
554. Zur Physiologie des Gehirns. Christiani, 1885.
555. De la paralysie du moteur oculaire externe avec déviation conjugée, 1878.
556. Ueber die Bewegung der Iris. Budge, 1855.
557. Illustrations of the Elementary Forms of Disease. Carswell, 1838.
558. Diseases of the Nervous System. Charcot (Eng. Transl., N. Syd. Soc.), 1877.
559. Maladies du système nerveux. Vulpian, 1886.
560. Die Porencephalie. Kundrat, 1882.
561. Traité de la régénération des os. Ollier, 1867.
562. Die normale Regeneration des Knochengewebes, etc. Kolliker, 1873.
563. Anzeiger d. k. Akad. d. Wissensch., Wien.
564. Dictionary of Practical Surgery. Heath, 1887.
565. Neues Handworterbuch d. Chemie. v. Fehling, 1878.
566. Text-book of Anatomy. Quain and Sharpey.
567. Illustrated Med. News.
568. Text-book of Chem. Physiol. and Pathol. Halliburton, 1891.

NO.
569. Chem. Centralblatt.
570. Jahresb. üb. d. Fortschr. d. Chem.
571. Die Coelomtheorie. Hertwig, 1881.
572. Collected Works. F. M. Balfour.
573. Die Mikroorganismen d. Mundhöhle. Miller, 1889.
574. Congress f. inn. Med., Berlin.
575. Traité pratique de bactériologie. Macé, 1892.
576. Inaug.-Dissertation, Würzburg. Reimann, 1887.
577. Inventum novum ex percussione thoracis humani. Auenbrugger, 1761.
578. Bakteriologische Diagnostik. Eisenberg, 1891.
579. Colour-blindness, etc. Edridge-Green (Internat. Scientific Series), 1891.
580. Berichte d. bot. Gesellsch.
581. Verhandl. d. deut. Gesellsch. f. Chirurg.
582. New Sydenham Soc. Publications.
583. Centralbl. f. Bakteriolog. u. Parasitenkunde.
584. Traité pratique de bacteriologie. Macé, 1892.
585. Chimie biologique. Duclaux.
586. Die niederen Pilze. Nägeli, 1877.
587. Die Spaltpilze. Zopf, 1885.
588. Bacteria and their Products. Woodhead, 1891.
589. Lectures on Bacteria. de Bary (Eng. Transl.), 1887.
590. Soc. méd. des hôp.
591. Arch. f. wissen. u. prakt. Thierheilk.
592. Proceedings of Congress for Hygiene and Demography, Lond. 1891.
593. Clinical Lectures on Mental Diseases. Clouston, 1883.
594. Pulmonary Tuberculosis. Philip, 1891.
595. Lehrbuch d. path. Mykologie. Baumgarten, 1890.
596. Congenital Obliteration of the Bile-ducts. Thomson, 1892.
597. Lehrbuch d. spec. Path. u. Therap. d. Hausthiere. Friedberger and Froener, 1889.
598. Der . . . Gonococcus-Neisser. Bumm, 1887.
599. Laboratory Reports, Royal Coll. of Phys. Edin.
600. Ueb. d. nächste Einwirkung gespannter Wasserdämpfe auf Proteïne, etc. Neumeister, 1889.
601. Beiträge z. Bestimmung d. Acidität d. Magensaftes. Hirsch, 1887.
602. Die chemische Diagnose d. Magenkrankheiten. Wille, 1889.
603. Arbeiten a. d. kaiserl. Gesundheits-Amt.
604. Manual of Path. Coats, 1889.
605. Leçons sur la système nerveux. C. Bernard.
606. Traité de physiol. Longet, 3me éd.
607. Elements of Physics. Neil Arnott.
608. Untersuch. üb. d. Entwickelung d. Glandula thymus, G. thyroidea, u. G. carotica. Stieda, 1881.
609. Coloration des Cils des Bactéries. van Ermengem. Reprint of Communication made to the Société de Méd. de Gand, 2nd May 1893.
610. System of Medicine. Reynolds.
611. Wien. klin. Wochnschr.
612. Aetiol. des Erysipels, 1883.
613. Manual of Bacteriology. Sternberg, 1892.
614. Morgagni.
615. Path. u. Therap. d. Hautkrankheiten. Kaposi, 1887.
616. Diseases of the Skin. Hebra (Eng. Transl., N. Syd. Soc.), 1868.

NO.
617. Diseases of the Skin. Crocker, 1888.
618. Diseases of the Skin. M'Call Anderson, 1887.
619. N. Y. Med. Journ.
620. Manual of Dermatology. Robinson, 1885.
621. Rivista sperimentali di Fremiatria et di medicina legale.
622. Monatschr. f. prakt. Dermatol.
623. Trans. Roy. Soc. Arts.
624. Du paludisme et de son hématozoaire. Laveran, 1891.
625. Virchow's Internat. Festschrift.
626. Journ. f. prakt. Chem.
627. Beitr. z. Biol. d. Spaltpilze. Nencki, 1880.
628. Sur les alcaloides. Gautier, 1886.
629. Centralbl. f. Physiol.
630. Ptomaïnes, Leucomaines, and Bacterial Proteids. Vaughan and Novy, 1891.
631. Bidrag til Laeren om den salnalette eller septische Infection. Panum, 1856.
632. Ueber Ptomaïne. Brieger I, II, and III, 1885.
633. Recherches sur le choléra. Nicati and Rietsch, 1886.
634. Ueb. d. Natur d. Milzbrandgiftes. Hoffa, 1886.
635. Sur les alcaloides. Gautier, 1886.
636. Nature.
637. Leprosy in Brit. Guiana. Hillis, 1881.
638. Norsk Magazin for Laegevidenskab.
639. Die Methoden d. Bakterien-Forschung. Hueppe.
640. Arbeiten a. d. bot. Inst. zu Tübingen.
641. La maladie pyocyanique. Charrin, 1889.
642. Suppuration and Septic Diseases. W. Cheyne, 1889.
643. Die Aetiol. d. acuten Eiterungen. Steinhaus, 1889.
644. Allg. u. spec. Chirurg. Pitha and Billroth.
645. Centralbl. f. Bakteriol.
646. Annales de l'Inst. de path. et de bacteriol. de Bucharest, 2nd year 1893.
647. Die Enstehung der Entzündung. Leber, 1891.
648. Mikro-organismen bei den Wundinfectionskrankheiten des Menschen. Rosenbach.
649. Ueb. Faulnissbacterien und deren Beziehungen zur Septicämie. Hauser, 1885.
650. Untersuchungen üb. d. Aetiol. d. eitrigen Phlegmone. Passet, 1885.
651. Centralbl. f. allg. Path.
652. Arch. f. Thierheilk.
653. Untersuch. über d. Aetiol. d. Wundinfectionskrankheiten. Koch, 1878 (Eng. Transl., 1880).
654. Verhandlungen d. Cong. f. inn. Med. Wiesbaden.
655. Die Korperwarme des gesunden Menschen. Jürgensen, 1873.
656. Ueb. Wesen u. Behandlung des Fiebers. Buss, 1878.
657. La chaleur animale. Richet, 1889.
658. Characteristik. des Arterienpulses. Wolff, 1865.
659. Fever ; a Study in Morbid and Normal Physiology. Wood, 1880.
660. The Principles and Practice of Medicine. Hilton-Fagge, 1888.
661. Reps. Royal Coll. Physicians Edin. Laboratory.
662. Maladie de Paget. Wickham.
663. Entozoa. Cobbold, 1864.
664. Beitr. zur Aetiol. d. Wundstarrkrampfes. Nicolaier, 1885.
665. On Mycetoma. Carter, 1874.

INDEX

Abdomen, retentive power of, ii. 407
Abrin, ii. 1002
Abscess, formation of, ii. 1017; hepatic, 238, 239; of kidney, 297; of lung, 116; of mamma, 807; septic, i. 677
Absorption, i. 265
Acardiacus, ii. 944
Acarus folliculorum, ii. 1082
Accommodation, ii. 705
Acetic acid fermentation, ii. 979
Acetonæmia, i. 531
Achromatic figure, i. 353
Acidity of blood, i. 450
Acids, and alkalies, action on vessels, i. 327; gastric, analysis of, ii. 492
Acne, ii. 887, 888
Acrania, ii. 921
Acrodynia, ii. 872
Acromegaly, ii. 774
Actinomyces, staining of, i. 138
Actinomycosis, ii. 1021
Acute ascending paralysis, ii. 758
Addison's disease, ii. 781
Adenoid post-nasal growths, ii. 456
Adenoma, i. 164, 400; of liver, ii. 244; of mamma, 800; of pineal gland, 739
Adhesions, i. 243, 296
Ægophony, ii. 58
Aerobes, ii. 966; and anaerobes, 984
Agar-glycerine, i. 118
Agar medium, i. 115
Age, i. 467
Aglobulia, i. 461, 496, 497
Agnathia, ii. 918
Agraphia, ii. 666
Ague, spleen of, ii. 789
Air embolism, i. 207, 689
Air, expired, testing, i. 155; testing for germs, 152
Air-vesicles, rupture of, ii. 170
Albukalin, i. 511
Albumin, an emulsion, i. 322; a general excretion, ii. 312; non-excretion from kidney, 312; point of excretion in disease, 312; quantitative analysis of, 320; tests for, 317
Albuminoid disease, i. 167
Albuminoids, fermentation of, ii. 983
Albuminous liquids, i. 321
Albumins, fermentation of, ii. 983
Albuminuria, i. 210, ii. 290, 311; causes of, 311; cyclical, 316; definition, 311; dietetic, 315; in exophthalmic goitre, 315; hæmatogenous, 311; in health, 315; and heart disease, 316; hereditary, 314; intermittent, 316; from inunction of skin, 315; and life insurance, 317; mechanism, 313; from medicinal agents, 316; from mental fatigue, 315; and organic disease of kidney, 316; renal, 311; varieties of, 314
Albumoses, ii. 474, 935, 993
Albumosuria, ii. 321
Alcohol, and digestion, ii. 479; effects of excess, 284; effects on liver, 212; and excretion of urine, 328
Alcoholism, ii. 762
Alkalinity of blood, i. 450
Alkaloids, bacterial, ii. 985, 986
Allantois, ii. 914; cloaca, 937
Alopechia, ii. 908
Alum-carmine, i. 78
Alveolar sarcoma, i. 371
Amaurosis, ii. 286
Amenorrhœa, ii. 389
Ammonia, i. 472
Amnesia, ii. 666; verbalis, 667
Amnion, ii. 912
Amœba coli, ii. 1051
Amœboid movement theory, i. 233
Amphoric breathing, ii. 56
Amyloid, i. 167; artificial, 170; bodies, 170, ii. 165; liver, 229
Amyotrophic lateral sclerosis, ii. 757
Anæmia, i. 328, 496, 568, 571, 705; in Addison's disease, ii. 781; degrees of, i. 497; from hæmorrhage, 499; from organic disease of stomach, 500; per-

nicious, 502 ; from valvular disease, 500 ; varieties, 499
Anæmic constitution, i. 500
Anaerobes, ii. 966
Anasarca, i. 330
Anastomosis, i. 689
Anchylostoma duodenale, ii. 1063
Aneurism, i. 590, 662, 670 ; pulse in, 713
Aneurismal varix, i. 670
Aneurisms, pulmonary, ii. 138
Angeioma, ii. 450
Angeiomata, i. 393
Angeio-neuroses, ii. 869
Angeio-sarcoma, i. 374
Angina, lacunaris sive follicularis, ii. 10, 11 ; pectoris, i. 575
Angle of aperture, i. 100
Aniline dyes, i. 84
Animal parasites, ii. 1051 ; of lung, 179
Anosmia, ii. 5
Antagonism of microphytes, ii. 977
Anthracosis, ii. 91
Anthrax, ii. 297, 510, 910, 978, 989, 1040 ; bacillus, 1042 ; life history, 1045 ; preventative inoculation, i. 142 ; symptomatic, ii. 1046
Antiabrin, ii. 1003
Antitoxine, ii. 999, 1000
Aortic disease, i. 624, 629 ; and mitral disease, 625, 639 ; notch, 701 ; valve, 610, 615
Aphasia, ii. 656 ; ataxic or motor, 660 ; meaning of terms, 656 ; motor, anatomy of parts in, 664 ; sensory or amnesic, 666
Apnœa, ii. 64
Apochromatic lenses, i. 101
Apoplexy, ii. 600 ; splenic, 1042 ; spurious, 602
Arachnida, ii. 1079
Archinephric duct, ii. 929
Argyria, i. 179
Arterial dilatation, i. 324 ; pressure, 323, healthy, 694, high, gauging of, 707, means of modifying, 704, measurement, 697, and disease, 705 ; recoil, 630, 695 ; tension, 550
Arteries, i. 660 ; anastomosis, 689 ; calcification, 669 ; closure after ligature, 305 ; contracted, 695 ; healing of, 674 ; hyaline degeneration, 673 ; hypertrophy, 669 ; ligatured, 666 ; simple fatty degeneration, 663 ; syphilitic, 664 ; terminal, 679 ; wounded, healing, 306
Arteritis, atheromatous, i. 661 ; deformans, 661 ; malignant, 668 ; obliterans, 664 ; points of distinction in various forms, 665 ; purulent, 667 ; warty, 667
Artero-capillary fibrosis, i. 672 ; sclerosis, ii. 283
Arthritis, ii. 855 ; deformans, 859
Arthropoda, ii. 1079
Arthrospores, ii. 967
Ascaris, lumbricoides, ii. 1062 ; mystax, 1063
Ascites, i. 330, 333
Aspergillus, ii. 962 ; glaucus, 960
Asphyxia, ii. 63
Asthenia, cardiac, i. 575
Asthma, ii. 64 ; bronchial spasm, 65 ; Clark's theory, 66 ; Curschmann's spirals, 68 ; diaphragmatic spasm, 65 ; Leyden's crystals, 67 ; Leyden's theory, 67 ; pulse in, i. 713
Ataxia, hereditary, ii. 751 ; locomotor, 746 ; paraplegia, 750
Atelectasis, ii. 171
Atheromatous arteriitis, i. 661, 713
Atmospheric germs, Hess's method, i. 153 ; Miquel's method, 153 ; Pawlowsky's apparatus, 154 ; testing for, 153
Atresia ani, ii. 937
Atrophy, i. 32, 170 ; of muscles, ii. 755
Atropine, i. 326
Attenuation by chemical reagents, i. 145 ; by compressed oxygen, 145 ; by heat, 143 ; by light, 146 ; of microbes, 141 ; of moulds, 146
Auditory cortical centre, ii. 623
Automatic burner, Koch's, i. 130
Axillary glands in cancer of mamma, ii. 802
Axis-cylinders, swollen, ii. 576, 584
Azoturia, ii. 327

BACILLI, cancerous, i. 407 ; tubercular, 434, 419 ; syphilitic, 440
Bacillus, ii. 964 ; aceti, 979 ; amylobacter, 981 ; of anthrax, 1042 ; butyricus, 981 ; Chauvaei, 1046 ; coli, 972 ; diphtheriæ, 16 ; fluorescens liquefaciens and non-liquefaciens, 975, 976 ; fluorescens putridus, 975 ; fœtidus ozænæ, 4 ; fuscus, 975 ; of glanders, 1034 ; of influenza, 1029 ; intracellularis meningitidis, 1013 ; janthinus, 974 ; of leprosy, 898 ; luteus, 974 ; mallei, 975 ; pneumoniæ, i. 605 ; pyocyaneus, ii. 959, 975, 1014 ; pyocyaneus, fluorescence of, 976 ; pyogenes fœtidus, 1013 ; septicæmiæ hæmorrhagicæ, 1019 ; septicus vesicæ, 1015 ; tetanus, 1037 ; of tubercle, culture, [illegible] ; tuberculosis, 131, 135, 144 ; of typhoid, 988, 1014 ; smaragdinus fœtidus, 4 ; violaceus, 975
Bacteria, chemical products from, ii. 985 ; staining, i. 133
Bacterial life, conditions of, ii. 957
Bacteriology, practical, i. 112 ; systematic, ii. 957
Bacterio-purpurin, ii. 975
Bacterium termo, ii. 983
Balancing, derangements of, ii. 650
Balanitis, ii. 284
Baldness, ii. 908
Bartolini's glands, suppuration of, ii. 421

Basal ganglia, diseases of, ii. 675

Beggiatoa, ii. 965 ; roseo-persicina, 974

Bidder's ganglion, i. 563

Bile absorption, ii. 194 ; acids, i. 470, ii. 194 ; and colour of fæces, 517 ; ducts and adenoma, 246 ; ducts in cirrhosis, 220, 221 ; ducts, origin, 183 ; pigmentation, i. 179 ; secretion of, ii. 184 ; tests, 202 ; uses of, 516

Bilharzia hæmatobia, ii. 1069

Biondi's fluid, ii. 1053

Bites, poisonous, i. 332

Bizzozero on thrombosis, i. 301

Bladder, ii. 354 ; abscess of, 361 ; catarrh of, 359 ; cavernous angeioma, 362 ; ectopia of, 915 ; examination of, i. 17 ; frog's, 216 ; gangrene of, ii. 360 ; hairy, 363 ; hernia of, 362 ; hypertrophy, 358 ; inversion of, 362 ; new formations in, 363 ; normal functions, 354 ; structure, 354 ; tonic function of muscle, 357 ; tuberculosis of, 363 ; villous disease, 362 ; wounds of, 361

Blastodermic vesicle, ii. 912

Blindness, cortical and psychical, ii. 695

Blood, i. 444 ; ash, 445 ; circulation of corpuscles, 192 ; circulation through tubes, 207 ; coagulation, 189, 300, 468 ; coloured corpuscles, 446, number, 447, size, 447, specific gravity, 448 ; colourless corpuscles, 448 ; copper-reducing substance in, 526 ; composition, dropsy, 327 ; corpuscle-holding cells, 497 ; corpuscles, 484, formation of, 494, giant, 497, in anæmia, 497, numeration, 455 ; corpuscular elements, 186 ; diabetic, sugar in, 525 ; disinfection of, 147 ; effect of physiological conditions, 465 ; examination, 475 ; extractives, 445 ; general character in health, 444 ; hæmatoblasts, 186 ; in chlorosis, 501 ; in gout, 542 ; in rheumatism, 536 ; leucocythæmic, 513 ; neutral fats, 445 ; plasma, 445 ; proteids, 445 ; quantity, 445 ; reaction, 449 ; serum, 116, 445, Unna's method, 118 ; sources of corpuscles, 476 ; sources of leucocytes, 476, 479 ; specific gravity, 328, 444 ; sugar in, 523 ; plates, 300, 340, 449, 463, 482, 484, 505 ; pressure, 234, 328

Blood-corpuscles, destruction, ii. 184

Blood-vessels, ii. 924 ; fatty, i. 674 ; healing, 271, 278, 280, 300 ; nerve supply, 660 ; normal structure, 660 ; peripheral and axial streams, 195 ; pernicious anæmia, 506

Bluish-pink pellicle, i. 276

Body-wall, fissures of, ii. 911

Boils, ii. 887

Bone, i. 312, ii. 811 ; absorption of, 813, 815 ; caries, 849 ; development of, 811 ; fracture with dislocation, 823 ; flat, ossification of, 814 ; fragilitas, 837 ; grafting, 817 ; growth of, 814 ; healing of fractured, 821 ; long, ossification of, 812 ; medulla, transplantation of, 820 ; mollities, 836 ; necrosis of, 824 ; osteitis, 826 ; parasitical diseases of, 865 ; porosis of, 843 ; regeneration, i. 308 ; rickets, ii. 830 ; sclerosis of, 841 ; syphilitic, 843 ; transplantation of dead, 819 ; tubercle of, 846 ; tumours of, 863 ; tumours of, terms, i. 368

Bone-marrow, i. 477 ; as blood transforming organ, 489 ; in p. anæmia, 506

Bothriocephalus latus, ii. 1075

Bouillon, i. 112

Brain, i. 620 ; abscess of, ii. 586 ; chemical reaction, 597 ; circulation within, 589 ; embolism of, 606 ; examination, i. 20, 45 ; gelatine-potash method, 48 ; general structure of, ii. 626 ; Giacomini's process, i. 47 ; hæmorrhage into, subsequent changes, ii. 603 ; hypertrophy of, 577 ; infarction, i. 682 ; involution following destruction of parts, ii. 735 ; membranes of, 567 ; membranes, tumours of, 574 ; pernicious anæmia, i. 506 ; Pitres' sections, 22 ; pressure, ii. 592 ; pressure, treatment of excessive, 596 ; variations in volume, 597

Branchial arches, malformations of, ii. 917 ; clefts, 916

Bread-paste, i. 119

Bright's disease, ii. 264

Broad ligaments, structure and diseases, ii. 422

Broca's convolution, ii. 658

Bromine, i. 150

Bronchi, ii. 72 ; arteries, 39 ; repair of epithelium, 72 ; structure and attachments, 72 ; tuberculosis of, 90 ; veins, 41

Bronchial glands, lithosis, ii. 100 ; tubercular, 143

Bronchiectasy, ii. 85, 100, 139 ; sputum, 89

Bronchitis, i. 644, 705 ; acute catarrhal, ii. 74 ; chronic, 78 ; cirrhosis from, 83 ; croupous, 84 ; fœtid, 84 ; organisms, 83 ; sputum, 83

Bronchocele, ii. 776

Bronchophony, ii. 57

Brown induration, ii. 173

Bruits, i. 653, 654

Buchanan on coagulation, i. 340

Bulbar paralysis, ii. 683, 751

Burns, duodenal ulcer after, ii. 520

Bursæ, accumulations in, ii. 863

Butyric acid fermentation, ii. 981

CADAVERINE, ii. 987, 988

Calcification, i. 182, 592, 613, 662, 669, ii. 813

Calculi, prostatic, ii. 338 ; urinary, 336

Calculus, i. 338

Callus, ii. 822
Camera lucida, i. 106
Camphor mounting fluid, i. 94
Canada balsam, i. 95
Canal of Gartner, ii. 930
Cancer, i. 400, ii. 154; bacillus, i. 407; blood-vessels, 403; bodies, ii. 1052; degenerations, i. 408; formation, 403; of liver, ii. 190; lymphatic infection, i. 407; malignancy, 407; of mamma, ii. 801; melanotic, i. 408
Cane-sugar, ii. 490
Capillaries, i. 326, 620, 660; fatty, 674; hyaline, 673; obstructed, 695; wax-like, 169, 674
Carbolic acid, i. 149
Carbon, assimilation by moulds, ii. 961
Carbonate of ammonia, i. 549
Carbonic acid a diuretic, ii. 328
Carbonic oxide, i. 526
Carcinoma of lung, ii. 177
Cardiac, asthenia, i. 575; ganglia, 563; nerves and heart's metabolism, 566; plexus, 561; thrombi, 622
Cardinal symptoms of inflammation, i. 259
Cardiodynia, i. 575
Caries, ii. 849; dental, 866
Carmine, i. 77; and freezing fluid, 78
Carnification, ii. 168
Cartilage, i. 312; inflammation of, 259
Cartilages, articular, ii. 814; articular, calcified, 862; loose, 862
Cartilaginous tumour, hyaline, i. 384
Carton-pierre, i. 718
Caseation, i. 180, 267, ii. 131
Casein, i. 341
Casts, i. 715
Catarrh of nares, ii. 1
Catarrhal nephritis, ii. 266; absorption from tubes, 270; causes, 273; colloid in tubes, 271; heart and vessels, 273; interstitial complication, 270; morbid anatomy, 121; pneumonia, i. 243, ii. 100, 119; suppuration, i. 262, 264; urine in, ii. 272
Cathcartine, i. 716, 717
Caton, instrument for fish tail, i. 217; instrument for tadpole's tail, 216
Caudate nucleus, ii. 675
Caustic action of cleft-fungi, ii. 972
Cavernous angeioma, ii. 362; breathing, 56; angeiomata, i. 393
Cavities, healing of, in lung, ii. 144; phthisical, 137, 141, 144
Cell, definition, i. 349
Celloidin, i. 60
Cells, division, direct, i. 356; indirect division, 351; methods of demonstrating, 357; pathological division, 355; reproduction, 359; structure, 349
Cercomonas intestinalis, ii. 1055
Cerebellum, ii. 680; hæmorrhage into, 602; rigidity after, 677
Cerebral, aneurisms, i. 671; convolutions, ii. 613; cortex, lesions of, 613; hæmorrhage, 600; vesicle, malformations of, 923
Cerebritis, ii. 582
Cerebro-spinal liquid, i. 344, ii. 592; normal pressure, 593; phenomena following varying pressure, 593
Cestoda, ii. 1070
Chalk metastasis, i. 182
Chancre, hard, i. 315; soft, 317
Charcot-Robin crystals, i. 511
Chauveau's system of attenuation, i. 143
Cheilo-schisis, ii. 917
Cheyne-Stokes breathing, ii. 70
Chiasma, lesions of, ii. 695
Chilblains, ii. 872
Chimiotaxis, ii. 1006
Chloasma, ii. 868
Chloral, i. 150, 527
Chlorine, i. 150
Chloroform, i. 527
Chloroma, i. 506
Chlorophyll, ii. 959
Chlorosis, i. 509
Cholagogues, ii. 205
Cholera Asiatica, i. 550, ii. 544, 989; spread of, 553; state of intestine in, 552
Cholera nostras, ii. 542; spirillum of, 548; spirillum, early recognition, 550; vaccination against, 1001
Cholesteatomata, ii. 738
Cholin, ii. 987
Chondroclasts, ii. 813
Chondroma, i. 384, ii. 805; of lung, 176
Chordæ tendineæ, rupture, i. 620
Chorea, ii. 761
Chromatic figure, i. 352
Chronic interstitial nephritis, ii. 277; pneumonia, i. 646, ii. 138
Chronic rheumatic arthritis, ii. 858
Chyluria, ii. 324
Cicatrised area, i. 278
Cicatrising layer, i. 275
Cicatrix, i. 271, 681
Cilia, ii. 969; and diagnosis, 971; staining of, 969
Cinnabar, circulation through tubes, i. 209
Circulation, blood-corpuscles, i. 211; of lymph, 321; through capillary tubes, 207; through tubes, 196
Cirrhosis, ii. 216; bile ducts, 220, 221, 223; of lung, 138
Cirrhosis of liver, calcified, ii. 225; cancerous, 225; in children, 226; clinical phenomena, 223; complications, 226; in lower animals, 226; lupinous, 225; nature of process, 223; tubercular, 225; varieties, 225
Cirrhotic kidney, ii. 277; arterial pressure, 282; causes, 284; dropsy, 283; heart and vessels, 282; retinitis, 285; theories of origin, 282; urine in, 285

Cirsoid aneurism, i. 670
Cladothrix, ii. 964 ; dichotoma, 975
Clarifying reagents, i. 90
Classification of mycetes, ii. 958
Cleft-fungi, ii. 964 ; antagonism, 977 ; caustic action, 972 ; fluorescence, 976 ; gas-forming, 976 ; influence of reaction of medium on, 968 ; influence of sunlight on, 974 ; influence of temperature on, 968 ; nomenclature, 964 ; nourishment, 956 ; pigment-forming properties, 974 ; powers of movement, 969 ; reproduction, 967 ; structure, 964
Cleft-palate, ii. 917
Cloaca, common open, ii. 937
Clostridium, ii. 964 : butyricum, 981
Clots, laminated, i. 671
Cloudy swelling, i. 172
Coagulation of blood, i. 300
Coagulative necrosis, i. 180
Coccidia, ii. 246, 1053
Coccidium oviforme, ii. 1052
Coccus, ii. 964 : in kidney, 298
Cohn's fluid, i. 113
Colic, ii. 500
Colloid bodies, i. 170 ; degeneration, 174 ; tumour of mamma, ii. 805
Colonies, counting of, i. 127
Coloration of blood-corpuscles, i. 484
Colour of organs, i. 34
Colour-blindness, ii. 697
Colour-sense, ii. 697 ; Edridge-Green's theory of, 701 ; Hering's theory of, 700 ; Young-Helmholtz theory of, 699
Colpitis, ii. 418
Comedone, ii. 887
Commissures of central nervous system, ii. 653
Common salt, i. 151 ; injection of, 528
Compound histioid neoplasmata, i. 392
Conception, ii. 389
Concretions, salivary, ii. 459
Concussion, ii. 598
Condylomata, i. 399
Conglutination, i. 301
Conjunctiva, transplanting, i. 307
Connective tissue, hypertrophy, i. 165
Contagion of anthrax, ii. 1045
Convolutions, cerebral, ii. 613
Cornea, gold and silver staining, i. 249 ; inflamed, 251, 252 ; structure, 245
Coronary arteries, i. 576
Corpora quadrigemina, ii. 713
Corpus callosum, course of fibres in, ii. 645 ; in edentata, 619 : function of, 651 ; secondary degeneration of, 650
Corpus luteum, ii. 428
Corpus quadrigeminum, ii. 689
Corrigan, pulse, i. 712 ; theory of murmurs, 656
Corrosion preparations, i. 75
Corrosive sublimate, i. 149
Coryza, ii. 1
Cotton plugs, i. 121
Coughing, ii. 69
Counting of colonies, i. 127
Covering and cementing, i. 96
Crackling, ii. 56
Crack-pot sound, ii. 60
Cranial topography, ii. 611
Craniopagus, ii. 944
Creatin, ii. 348
Creatinin, ii. 348
Crepitation, ii. 56
Cretinism, ii. 776 ; fœtal, 777
Crise hématique, i. 483
Crossed callosal tract, ii. 645
Croup, ii. 10
Croupous exudation, i. 235
Croupous pneumonia, i. 689, ii. 102 ; complications, 109 : and embolism, 109 : microphyte, 106 ; sputum, 106 ; state of heart, 105 ; suppuration in, 105 ; and temperature, 108 ; termination, 106
Crusta, diseases of, ii. 677
Cryptorchid, ii. 371
Culture media, i. 112, 114, preservation, 120 ; tubes, 120
Curare, ii. 985
Curschmann's spirals, ii. 68
Cyanotic atrophy, ii. 212 ; induration of kidney, 288
Cyclopia, ii. 923
Cylindroma, i. 375
Cyphosis, ii. 865
Cyrtometer, ii. 164
Cyrtosis, ii. 865
Cysticercus cellulosæ, ii. 1073
Cystinuria, ii. 330
Cystitis, ii. 359
Cysts, i. 407, 414, ii. 914 ; of liver, 247 ; of mamma, 796, 799, 805

DAMMAR LAC, i. 96
Decalcifying fluid, i. 97
Decomposition, i. 183
Degenerations, i. 170 ; atrophy, 170 ; calcification, 182 ; caseation, 180 ; coagulative necrosis, 180 ; cloudy swelling, 172 ; colloid, 174 ; fatty, 173 ; gangrene, 183 ; of hypertrophied heart, 650 ; mucoid, 176 ; pigmentation, 177
Demodex folliculorum, ii. 1082
De Renzi, reaction of blood, i. 450
Desquamative nephritis, ii. 266
Development, i. 162
Dextrins, i. 521
Diabetes, ii. 330 ; causes, i. 528 ; insipidus, 520, ii. 327 ; mellitus, i. 520 ; organs in, 529 ; pancreatic, ii. 560
Diabetic coma, i. 533 ; organs, preparation, 534
Diaceturia, i. 532
Diapedesis, i. 224, 230, 233 ; history, 229
Diarrhœa, ii. 537 ; green, 538 ; green, of infants, 975 ; summer, of children, 537

Diastatic ferments, ii. 979
Dicephalus, ii. 945
Dicrotic wave, i. 701 ; pulse, 709
Diet and urine, ii. 339
Diffuse aneurism, i. 670 ; waxy spleen, ii. 787
Digestion, alcohol in, ii. 479 ; circumstances influencing, 478 ; disordered, i. 572 ; in horse, ii. 477 ; influence of acids and alkalies on, 480 ; influence of depressing nerve influences on, 481 ; infused beverages in, 479 ; nerve control over, 481 ; normal, 468 ; in overloaded stomach, 480 ; of particular elements of the food, 481 ; of proteids, 473
Dilatation, i. 628
Diphtheria, i. 607, ii. 10, 762 ; bacillus of, 977 ; Bretonneau, 14 ; general conclusions, 22 ; in lower animals, 27 ; older views, 13 ; urine in, 27
Diphtheritic bacillus, ii. 16 ; paralysis, 24
Diplococcus, ii. 1010
Dipygus, ii. 946
Direct division of cells, i. 356
Discharge from wound, i. 278, 283
Disease, definition of, i. 161
Diseases with high arterial pressure, i. 705; with low arterial pressure, 708
Disinfectants—carbolic acid, i. 149 ; chloral, 150 ; chloride of zinc, 150 ; chlorine, bromine, and iodine, 150 ; common salt, 151 ; corrosive sublimate, 149 ; ozonised air, 151 ; phenylpropionic and phenylacetic acids, 151 ; sulphurous acid, 150 ; thymol, 149
Disinfection, i. 147 ; of blood, 147 ; method of experiment, 148 ; organisms of suppuration, 151
Dissecting aneurism, i. 670
Diuresis, ii. 327
Diverticulum ilei, ii. 913
Division of pathological cells, i. 355
Dochmius duodenalis, ii. 1063
Dracunculus medinensis, ii. 1068
Drawing, microscopic, i. 106
Dropsical liquids, i. 340 ; coagulation, 340 ; decomposition, 342 ; proteids, 342 ; proteids and diagnosis, 344
Dropsy, i. 318 ; definition, 322 ; general causes, 323 ; nomenclature, 330 ; special, 330
Dry lenses, i. 101
Dull sound, ii. 59
Duodenum, acute perforating ulcer of, ii. 520 ; dilatation of, 521
Dysentery, ii. 549 ; English, 542
Dysmenorrhœa, ii. 390 ; membranous, 394
Dyspepsia, ii. 487 ; acid, 488 ; from fats, 497 ; fermentation test in, 498 ; flatulent, 497 ; pathology of symptoms, 501 ; from proteids, 496
Dysphagia, ii. 464
Dyspnœa, ii. 61

EAR, enlargement of, in rabbit, i. 324
Earthworms and anthrax, ii. 1045
Eberth and Schimmelbusch on thrombosis, i. 301
Eburnation, ii. 857
Ecthyma, ii. 879
Ectopia vesicæ, ii. 915
Eczema, ii. 878
Eichorst's corpuscles, i. 497, 505
Elephantiasis, ii. 893
Elythritis, ii. 418
Embedding, i. 60 ; mixture for bone and tooth, 62
Emboli, septic, i. 677
Embolic infarction, ii. 285, 310
Embolism, i. 677 ; air, 207, 689 ; encephalic, ii. 606 ; fat, i. 687 ; and inflammation, 235 ; pulmonary, 685
Emesis, ii. 500
Emphysema, i. 641, 705, ii. 161
Empyema, ii. 35
Encephalitis, ii. 582
Encephalocele, ii. 923
Endoarteriitis chronica, nodosa s. deformans, i. 661 ; verrucosa, 667
Endocarditis, i. 595 ; chronic changes, 599 ; diabetic, 607 ; from gout, 600 ; idiopathic, 609 ; malignant, 600 ; morbid anatomy, 596 ; organisms of, 601, 603, 604, 605 ; pneumonic, 607 ; rheumatic, 595 ; sites, 596
Endocardium, structure, i. 594
Endometritis, ii. 392 ; acute, 392 ; chronic, 393 ; gangrenous, 396 ; membranous, 394
Endothelial desquamation, i. 240
Endotheliomata, ii. 738
Endothelium, i. 397 ; of vessels, 483
Enteritis, croupous, ii. 542
Enteroliths, ii. 556
Enuresis, ii. 357
Enzymes, ii. 978, 985 ; bacterial, 992
Eosin, i. 83
Ephelides, ii. 868
Epididymitis, ii. 374
Epignathus, ii. 945
Epilepsy, ii. 739 ; artificial, 741 ; nerve centres in, 741
Epiphysial line, ii. 814
Epispadia, ii. 937
Epistaxis, ii. 2
Epitheliomata, i. 397
Epithelium, i. 397 ; of air-vesicles, ii. 120 ; in healing, i. 268, 273 ; pulmonary, 243 ; regeneration, 307
Erb's paralysis, ii. 755
Erysipelas, ii. 873, 978, 1104
Erythema, ii. 869, 871 ; nodosum, 872
Esbach's tubes, ii. 320
Esmarch's method, fractional culture, i. 126
Essential paralysis, ii. 753
Etiology of pulmonary tuberculosis, ii. 151
Eucalyptol, i. 233

Eustrongylus gigas, ii. 1064
Exudation, inflammatory, i. 235 ; of liquid, 232
Exudations, i. 319, 330
Eyeball, effect of destruction, ii. 692
Eyeballs, movements of, ii. 706

Facultative parasites, ii. 958
Fæces in jaundice, ii. 191
Fallopian tubes, ii. 411 ; atresia, 412 ; hæmorrhage from, 412 ; hydrops of, 411
False aneurism, i. 670 ; membranes, 235, ii. 15
Farrants' solution, i. 93
Fat embolism, i. 207, 533, 687, ii. 296
Fat-splitting ferment, ii. 473
Fatty degeneration, i. 173, 581 ; heart, medico-legally, 585 ; infiltration, 166, 581, ii. 208 ; tumour, i. 383
Favus, ii. 903
Ferment, fat-splitting, ii. 473 ; lactic acid, 473 ; milk-curdling, 472
Fermentation, ii. 960, 964, 978 ; butyric acid, 981 ; chemical interchanges, 979 ; by cleavage, 980 ; continuous, 979 ; by microbes, 980 ; by oxidation, 979 ; by reduction, 980 ; by schizomycetes, 981 ; by yeast, 980
Fermentations, organic, ii. 980
Ferments, ii. 978, 985 ; bacterial, 992 ; organised, 978 ; of stomach, fate of, 483
Fever, i. 345, ii. 1096 ; cause of death in, 1102 ; products of metabolism, 1100 ; puerperal, 396 ; relapsing, 1047 ; respiratory and circulatory phenomena, 1102 ; rise of temperature after death in, 1103 ; a salutary process, 1103 ; source of heat, 1102 ; splenic, 1042 ; stages, 1096 ; temperature in, 1097 ; traumatic, 1100
Fevers, different, temperature in, ii. 1103
Fibrinous lymph, i. 296
Fibroblasts, i. 271
Fibro-chondroma, i. 386
Fibroid phthisis, i. 646, ii. 138
Fibroma of mamma, ii. 797
Fibrous tissue, and healing, i. 271 ; regeneration, 307 ; tumour, 381
Filaria sanguinis hominis, ii. 324, 893, 1066
Filtering organisms, i. 132
Fish tail, i. 217
Fissura abdominalis, ii. 915
Fissura sterni, ii. 916
Fistula in ano, ii. 146
Fistula colli, ii. 920
Fistula, lymph, i. 342 ; salivary, ii. 459
Flat sound, ii. 59
Flat worms, ii. 1070
Flatus, ii. 499
Flesh, tubercular, i. 434
Flies as disseminators of contagion, ii. 1046
Floating kidney, ii. 310
Flukes, ii. 1068
Fluorescence of organisms, ii. 976
Fœtal membranes, diseases of, ii. 949 tissues, transplantation, i. 311
Fœtus, harlequin, ii. 885 ; tubercular, 952
Fourth ventricle, puncture, i. 527
Fowls, tubercular infection from, i. 433
Fractional cultivation, i. 124
Freckles, ii. 868
Freezing fluids, i. 58
Friction sound, ii. 57 ; theory of murmurs, i. 656
Friedreich's disease, ii. 751
Frog's bladder, i. 216 ; lung, 215 ; mesentery, 215 ; tongue, 215, 225 ; web, circulation, 192, 214
Fungi, classification, 958 ; functions of, 959
Fungous granulations, ii. 852
Fungus benignus, ii. 376
Furunculi, ii. 887
Fusiform aneurism, i. 670

Gadinin, ii. 987
Gall-bladder, diseases of, ii. 207 ; in fatty liver, 211
Gall-stones, ii. 208
Ganglion, ii. 863
Gangrene, i. 183 ; of lung, ii. 117
Gangrene-lung, ii. 100
Gartner's canal, cyst of, ii. 424
Gas cysts, ii. 556 ; of vagina, 420
Gas in pleura, ii. 168 ; in stomach, absorption of, 498
Gastric juice, ii. 471
Gastro-schisis, ii. 915
Gastroxia, ii. 491
Gastroxynsis, ii. 491
Gelatine and freezing fluid mixture, i. 61
Gelatine-potash method—brain, i. 48
Gélose, ii. 969
Genital cord, ii. 931 ; glands, malformations of, 928 ; organs and passages, malformations of, 934 ; tuberculosis, 410
Genito-urinary phthisis, ii. 303 ; tuberculosis, 146
Germicides, ii. 156
Germs, atmospheric, testing, i. 152
Giant-cells, i. 291, ii. 815, 816
Gibson on blood-corpuscles, i. 493
Gilder's putty, i. 719
Gin-drinker's liver, ii. 216
Gland tissue, inflamed, i. 244
Glanders, ii. 989, 1032
Glands, lymphatic, cancer of, ii. 802
Glans penis, ii. 383
Glass troughs for cultures, i. 126
Glioma, i. 373
Gliomata, ii. 737
Globulin, tests for, ii. 317, 320
Glomerulo-nephritis, i. 647, ii. 291
Glosso-labial paralysis, ii. 683
Glycerine, i. 95 ; agar, 118 ; jelly, 44, 50, (Hamilton) 94

Glycogen, i. 521, ii. 188, 192; liver, 205; stain for, 205
Glycogenetic function, i. 521
Glycogenic function, i. 522
Glycosuria, i. 520; experimental, 527
Goitre, endemic, ii. 776; exophthalmic, 777
Gold stain, i. 88
Gold-stained cornea, i. 249
Golgi's stain, i. 83
Gonococcus, ii. 368, 977, 1014
Gonorrhœa, ii. 367
Gonorrhœal rheumatism, i. 535
Gout, i. 538, 705, ii. 284; diaphragmatic, i. 576; pathological anatomy, 543; theories, 544
Gouty kidney, ii. 277
Gowers, hæmoglobinometer, i. 453; numeration of blood-corpuscles, 459
Gram's process of staining, i. 134
Granite workers and dust disease, ii. 99
Granulation, healing by, i. 274; tissue, 274
Granulations of cerebral ventricles, ii. 574; flabby, i. 278; formation of, 278; fungous, ii. 852; influence in healing, i. 283; natural atrophy, 284
Grape-sugar, i. 341, 528; estimation of, ii. 333; tests for, 330
Gray hepatisation, ii. 104
Growth, i. 162
Guanin, ii. 348
Gubernaculum testis, ii. 371
Guinea-worm, ii. 1068
Gummata, i. 439, 664, ii. 236

HADERNKRANKHEIT, ii. 1041
Hæmacytometer, i. 455, 459
Hæmatoblasts, i. 300, 340, 449, 463, 482, (Hayem's) 186, 484
Hæmatocele, ii. 415, 421; pelvic, 426
Hæmatoidin, i. 178
Hæmatoma of dura mater, ii. 604
Hæmatoxylene, i. 79; regeneration, 82; stain (Hamilton), 81
Hæmatozoa, of animals, ii. 1061; of malaria, 1056
Hæmaturia, ii. 324
Hæmocytes, i. 462; sources of, 479
Hæmoglobin, i. 177, 341, 460, 462, 505; in disease, 454; estimation of, 450; tests for, ii. 324
Hæmoglobinometer, i. 452, 453
Hæmoglobinuria, ii. 322; in animals, 323
Hæmolysis and urine, ii. 323
Hæmophilia, i. 470
Hæmoptysis, ii. 135
Hæmorrhage, i. 461, 507, 510; cerebral, ii. 600; in infarction, i. 680; pericardial, 556; pulmonary, ii. 159; vital phenomena, i. 499
Hæmorrhagic infarction, ii. 179
Hairy polypus, ii. 3
Hard chancre, i. 315
Hardening, i. 54; brain, 56; solutions "A," "B," "C," etc., 54
Harelip, ii. 917
Harlequin fœtus, ii. 885
Harvest bug, ii. 1080
Haversian spaces, ii. 813
Hay fever, ii. 1
Hayem on thrombosis, i. 301
Headache, ii. 501
Head-kidney, ii. 928
Healing, i. 268; of arteries, 674; by first intention, 269; by immediate union, 268; method of studying, 273; by second intention, 274; by secondary adhesion, 285; under scab, 286; summary, 286
Health, definition of, i. 161
Heart, accelerated beat, i. 568, 569; aneurism, 590; base muscles, 621; branches of sympathetic, 560; branches of vagus, 561; calcification, 592; cloudy swelling, 583; contraction, 695, 697, 698; dilatation, 628; examination of, 6; fatty infiltration and degeneration, 581; fibre, examination of, 13; functional diseases, 559; hypertrophied degeneration, 650; hypertrophy, 629; idiopathic hypertrophy, 649; irregularity, 574; malformations of, 593, ii. 924; muscle, automatism, i. 564; myocarditis, 589; nerve supply, 559; orifices, 623; pernicious anæmia, 506; pigmentation, 587; retarded beat, 573; rhythm, 702; rupture, 587; syphilitic disease, 592; tonic function, 631; tumours, 593; valvular lesion, 570; wax-like disease, 588; weights and measurements, 578, in disease, 644, pregnancy, 650
Heartburn, ii. 499
Heart-disease, ii. 154
Heat, animal, ii. 1087; animal, localities in which generated, 1091; animal, sources, 1090; in asphyxia, 63; production and temperature, 1094
Heidenhain, excretion of albumin, ii. 3[illegible]
Hemialbumose, ii. 321
Hemianopsia, ii. 693
Hemiopia, ii. 693
Hemiplegia, ii. 588, 676
Hepatic colic, ii. 208
Hepatisation, ii. 104
Hermaphroditism, ii. 936
Hernia, congenital, ii. 372; funis, 915
Herpes, ii. 879; circinatus, 871; of glans and prepuce, 384; iris, 871; labialis, 445
Hess's method, atmospheric germs, i. 153
Hiccough, ii. 70
Hippocratic succussion, ii. 57
Hippuric acid, ii. 340
Hobnail liver, ii. 216
Hoppe-Seyler, hæmoglobin, i. 451
Horns, i. 399
Howship's lacunæ, ii. 815

Hyaline degeneration, i. 671, 673; fibroid substance, 673
Hyaline-fibroid, ii. 283
Hyboma, ii. 865
Hybosis, ii. 865
Hydatids, ii. 1076; of pleura, 37
Hydræmia, i. 328
Hydramnion, ii. 949
Hydrencephalocele, i. 330, 336
Hydrocele, ii. 373; congenital, i. 338, ii. 372; encysted, i. 338; in female, ii. 427
Hydrocephalus, i. 330, 333
Hydromeningocele, i. 336
Hydromyelia, i. 336
Hydronephrosis, i. 338
Hydropericardium, i. 330, 332, 557
Hydrophobia, prophylaxis, ii. 1002
Hydrops, ii. 429, 431; lacteus, i. 341
Hydrorachis, i. 330, 336
Hydrothorax, i. 330, 332
Hydruria, ii. 327
Hygroma, ii. 863
Hypalbuminosis, i. 466, 496
Hyperalbuminosis, i. 465, 496
Hyperinosis, i. 496
Hypertrophy, i. 32, 164, 628; of arteries, 669; of bladder, ii. 358; of brain, 577; of kidney, 302; of pulmonary muscle, 179; of testicle, 372; heart, time required, i. 650; from valvular disease, 628
Hyphomycetes, ii. 960
Hypinosis, i. 496
Hypinotic diseases, i. 471
Hypospadia, ii. 937
Hypoxanthin, i. 510, ii. 348

Ichthyosis, ii. 883
Icterus epidemius, ii. 200; neonatorum, 201
Immersion lenses, i. 101
Immunity, ii. 996; from antitoxic serum, 999; cause of, 1003; from disease, i. 146; regional and hereditary, ii. 1003; against ricin and abrin, 1002
Impetigo, ii. 878
Inanition, i. 466
Inclusio fœtalis, ii. 945
Incubation chamber, i. 128
Indigo and urine, ii. 336
Indigo-carmine, i. 79
Indirect division of cells, i. 351
Indol in cultures, ii. 994
Infantile spinal paralysis, ii. 753
Infarction, i. 602, 679, ii. 235; artificial, i. 686
Infiltrations, i. 166
Inflamed omentum, i. 241
Inflammation, i. 185; cardinal symptoms, 259; of cartilage, 259; changes in fixed tissues, 239; cold-blooded animals, 214, 222; connective tissue proliferation, 241, 242; definition, 185; endothelial desquamation, 240; exudation of liquid, 232; of gland tissue, 244; of lung, 243; of muscle, 243; nervous influence, 218; pain, 259; parenchymatous, 260; redness, 260; swelling, 260; temperature, 259; vascular and tissue changes, 185; vascular parts, method, 214; vascular phenomena, 222; warm-blooded animals, 226
Inflammatory affections of arteries, i. 661; effusion, fate, 265
Influenza, ii. 1028, 1104
Infused beverages and digestion, ii. 479
Ingesta and tuberculosis, i. 432
Injecting, i. 70; apparatus, 73
Injection of lymphatics, i. 75, 321
Inner capsule, lesions of, ii. 676
Inoculating a tube, i. 128
Inoculation of animals, i. 139; of tubercle, 431
Insanity, ii. 153
Insecta, ii. 1082
Insects as disseminators of contagion, ii. 1046
Intermittent fever, i. 551
Interstitial nephritis, i. 647
Intestine, ii. 515; catarrh of, 518; diseases of follicular tissue, 521; examination of, i. 17; gas cysts, ii. 556; intussusception of, 535; micro-organisms of, 517; obstruction of, 535; perforation of, 563; secretions and excretions poured into it, 515; tubercular, 146; tuberculosis, 531; tumours of, 555; venereal affections, 555; wasting of, 555; waxy disease, 554
Iodine, i. 150; stain, 89
Iodoform, i. 233, 293
Iron in blood, i. 450
Ischiopagus, ii. 944
Ischuria, ii. 358

Jacksonian epilepsy, ii. 739
Janiceps, ii. 944
Jars, museum, i. 52
Jaundice, ii. 190; from catarrh, 197; causes, 193; degrees of, 193; epidemic, 200; hæmatogenous, 193; from heart disease, 198; in infants, 201; nervous, 199; nervous phenomena, 192; without obstruction, 198; from obstruction of bile ducts, 194; from poisons, 199; from starvation, 198; terminations, 201
Johann Duncan, chlorosis, i. 460
Joints, ii. 811; arthritis deformans, 859; chronic rheumatic arthritis, 858; fungous, 849; in gout, i. 543; inflammation of, ii. 855; lipoma of, 863; in rheumatism, i. 536; senile changes in, ii. 857; suppurating, 856; syphilitic, 845; tubercle of, 846; tubercular, 846; wax-like disease of, 862

Keloid, ii. 892
Keratitis, i. 252; Cohnheim's early views, i. 252, later views, 253; method, 251; Stricker's views, 255; summary, 256; suppurative, 253
Kidney, abscess, ii. 297; adenoma, 307; anatomical and physiological details, 251; anthrax, 297; cancer, 306; catarrhal nephritis, 266; cirrhotic, 277; connective tissue, 257; course of tubes, 255; cyanotic induration, 288; cystic disease, 309; disease and cardiac hypertrophy, i. 647; diseases of pelvis, ii. 364; epithelium, 255; and excretion of nitrogen, 339; fat embolism, 296; fatty degeneration, 288; fatty infiltration, 287; fibrous tumour, 307; floating, 310; genito-urinary phthisis, 303; glomerulonephritis, 291; hæmorrhagic sarcoma, 306; hypertrophy, 302; innervation, 258; in jaundice, 192; in leucocythæmia, 301; lipoma, 306, 308; lymphatics, 257; myoma, 307; paranephritis, 301; parts concerned in excretion, 260; powers of excretion, 261; pyelo-nephritis, 298; replacement by fat, 308; sarcoma, 306; scarlet fever, 291; tubercle, 302; in valvular disease of heart, 288; wax-like, 273
Kidneys, i. 616; examination of, 15; in gout, 544; hypertrophy, 165; infarction, 680
Kjeldahl's process for estimating nitrogen, ii. 344
Knop and Hufner's process for estimation of urea, ii. 342
Koch's gelatine, i. 114

Lactic acid, i. 511, 537; ferment, ii. 473
Laenne on phthisis, ii. 130
Lardaceous disease, i. 167
Laryngismus stridulus, ii. 7
Laryngitis, acute membranous, ii. 10, 11; croupous, i. 235
Larynx, abscess, ii. 9; catarrh, 8; disease of cartilages, 30; functional diseases, 6; œdema, 9; organic diseases, 8; paralysis, 7; spasm, 7; spasm of muscles, 6; syphilitic, 30; tubercle, 28; tubercular, 146; tumours, 30; typhoid, 28; wasting of muscles, 8
Lateral sclerosis, ii. 757
Lead poisoning, i. 705, ii. 284
Leech secretion, i. 472
Leiomyoma, i. 388
Lenses, i. 101
Lenticular nucleus, ii. 675, 686; loop, 690
Leontiasis, ii. 896
Lepra, ii. 896
Leprosy, ii. 896; bacillus of, 898; and tubercle compared, 901
Leptomeningitis, ii. 569
Leptothrix, ii. 964
Leptus autumnalis, ii. 1080
Leucin, i. 511, ii. 345
Leucocytes, i. 449, 462, 481, 505; numeration, 458; proliferation of, 264
Leucocythæmia, i. 503, 508; etiology, 516; kidney in, ii. 301
Leucocythæmic blood, i. 449
Leucocytosis, i. 518
Leucomaines, ii. 991
Leuconostoc, ii. 967
Leucorrhœa, ii. 392; infantile, 421
Leukæmia, i. 508
Leukoplasia, buccal, ii. 448
Lichen, ii. 888; urticatus, 871
Liebig's method for estimating urea, ii. 341
Liebreich, reaction of blood, i. 450
Ligatures, i. 306
Lipæmia, i. 207, 530, 688
Lipoma, i. 383, ii. 565, 863
Lipomatous sarcoma, i. 378
Lips, ii. 443, 445; tumours of, 445
Lipuria, ii. 327
Liquid, exudation of, inflammation, i. 232; vein, 656
Liquids, dropsical, i. 340; preparation of for staining, 139; of tissues as solvents, 293
Lister's flask, i. 121
Lithates, ii. 347
Lithic acid, ii. 346
Lithopædion, ii. 415
Lithosis, ii. 97
Lithuria, ii. 335
Liver, i. 619, ii. 180; absorption by capillaries, 240; acini of, 182; acute yellow atrophy, 231; adenoma of, 222, 244; anatomical details, 180; bacterial necrosis, 235; calcified, 225; cancer, 190, 244; cells, division of, 219; cirrhotic, 216; cyanotic atrophy, 212; cysts, 247; deformities from pressure, 207; displacement of, 206; distribution of its vessels, 182; effect of extremes of diet on, 204; examination of, i. 14; fatty infiltration, ii. 208; fibromata, 248; functions, 183; infarction, 235; large cirrhotic, 220; malarious fever, 240; pain in disease of, 203; pathological zones, 181; phosphorous poisoning, 231; pigmentation, 242; pseudo-acute yellow atrophy, 233; pyæmic abscess, 239; sarcomata, 248; small cirrhotic, 216; syphilitic, 236; tropical abscess, 238; tuberculosis, 242; typhoid, 243; wax-like, 229
Locomotor ataxia, ii. 746
Lordosis, ii. 865
Louis on phthisis, ii. 129
Lung, abscess, ii. 116; acute atrophy of, 171; blood supply, 38; brown induration, 173; cirrhosis of, 138, 165; cirrhosis from bronchitis, 83; collapse, 165, 166; congenital deficiency of, 171; croupous pneumonia, 102; disease and cardiac

hypertrophy, i. 644 ; duct diseases, ii. 91 ; frog's, i. 215 ; functional diseases, ii. 61 ; gangrene, 100, 117 ; infarction, i. 683 ; œdema of, 339, 689, ii. 176 ; structural details, 38 ; syphilitic, 172 ; tubercle propagated by the blood-vessels, 147 ; tubercle propagated by lymphatics, 150 ; tubercular, in lithosis, 100 ; tuberculosis, 129 ; tumours of, 176 ; in valvular disease, i. 637 ; vaso-motor nerves, ii. 49
Lungs, examination of, i. 14
Lupinous cirrhosis, ii. 225
Lupus, i. 437
Lutein, i. 179
Lymph, circulation, i. 321 ; composition, 319 ; fistula, 342 ; glands, 477, 515 ; glands as blood-transforming organs, 493 ; hearts, 321 ; obstruction, 326
Lymphangeioma, i. 395, ii. 449
Lymphatic glands, examination, i. 19
Lymphatics, injection, i. 321 ; of endocardium, 595 ; pulmonary, ii. 146
Lymphoid tumours, i. 510
Lymphorrhœa, ii. 894
Lympho-sarcoma, i. 377 ; of lung, ii. 176

MACROCHEILIA, ii. 445
Madura foot, ii. 1027
Malacosteon, ii. 836
Malaria, ii. 1055
Malarious fever, ii. 240
Malassez, hæmoglobin, i. 452 ; numeration of blood-corpuscles, 455
Malformations, ii. 909 ; causes, 909 ; classification of, 909 ; of genito-urinary organs, 928 ; of heart and blood-vessels, 924 ; of limbs, 939 ; of primitive cerebral vesicle, 923 ; of skull and spine, 921
Malignancy, signs of, i. 360
Malignant pustule, ii. 1041 ; sore-throat, 11, 12
Mallein, ii. 989, 1087
Maltose, i. 520 ; fermentation of, ii. 981
Mamma, ii. 791 ; abscess of, 807 ; cancer, i. 403 ; hypertrophy of, ii. 146, 794 ; inflammation of, 794 ; lactating, 793 ; male, diseases of, 809 ; neuralgia of, 792 ; normal structure, 791 ; tubercular, i. 434, ii. 809 ; tumours of, 795 ; warty growth in cancer of, 806
Maniacs, pulse in, i. 714
Mannite, fermentation of, ii. 982
Mask, making of, i. 718
Mastitis, ii. 794
Mastodynia, ii. 792
Maternal impressions, ii. 911
Maxilla, inferior, ii. 917
Measles, ii. 910, 1103
Meckel's diverticulum, ii. 913
Medico-legal reports, i. 37, 41
Medulla oblongata, ii. 682 ; hæmorrhage into, 693
Megalocytes, i. 447, 462, 505
Melæna, ii. 520
Melanæmia, i. 551
Melanine, i. 178
Melanotic cancer, i. 408 ; sarcoma, 370
Mellituria, i. 520, ii. 330
Ménière's disease, ii. 680
Meningitis, i. 602, ii. 567 ; from ear disease, 573 ; epidemic cerebro-spinal, 573 ; tubercular, 570; vital phenomena, 574
Meningocele, i. 330, 336, ii. 923
Menorrhagia, ii. 389
Menses, retained, ii. 420
Menstruation, i. 467, ii. 153 ; and its disorders, 388
Merismopedia, ii. 964
Merycism, ii. 500
Mesentery, examination, i. 215, 217 ; inflamed, 222, 226, 239
Metalbumin, i. 341
Metallic tinkling, ii. 57
Methæmoglobin, ii. 322
Methyl-guanidin, ii. 988
Metritis, ii. 398
Metrorrhagia, ii. 389
M'Fadyean's tube, i. 120
Microbacterium, ii. 964
Microbes, attenuation of, i. 141
Micrococcus, i. 603; albicans amplus, ii. 977 ; albicans tardissimus, 977 ; cereus flavus, 974 : cinnabareus, 974 ; citreus conglomeratus, 977 ; lacteus faviformis, 977 ; luteus, 974 ; prodigiosus, 974 ; pyogenes tenuis, 1013 ; roseus, 974 ; subflavus, 977 ; tetragenus, i. 605, ii. 1013, 1049
Microcytes, i. 447, 462, 496
Microcythæmia, i. 496
Micro-organisms of suppuration, i. 263 ; of alimentary canal, ii. 517
Microscope, i. 98 ; accessories, 109 ; choosing a, 103 ; magnifying power, 107 ; testing a, 105
Microtome, Cathcart's, i. 67 ; large freezing, 64 ; Lewis's, 66 ; Rutherford's, 62, 63 ; Williams's, 66
Microtomes, i. 62
Micturition, ii. 356
Miescher's cylinders, ii. 1052
Miliaria, ii. 879
Miliary aneurism, i. 672
Milium, ii. 887
Milk, circulation of, through tubes, i. 208 ; spots, 558 ; tubercular, 433
Milk-curdling ferment, ii. 472
Miquel's method, atmospheric germs, i. 153
Mitral disease, i. 624, 638 ; valve, 611, 614
Models, i. 715, 718 ; of paper, 719
Moist chamber, i. 126
Moles, ii. 950
Molluscum, ii. 890 ; bodies, 891
Momentum of blood, i. 694
Monocrotic pulse, i. 711

Monsters, double and triple, ii. 940
Morbus Werlhofii, i. 545
Mordants, i. 133
Morphia, i. 527
Motor centres, ii. 614 ; effects of destruction, 621 ; in Man, 619 ; in monkey, 614
Moulds, ii. 960 ; chemical composition, 961 ; conditions of growth, 961 ; cultures of, 961 ; question of their becoming parasitic, 962 ; types of, 960
Mounting fluids, i. 93
Mouth, ii. 443, 446 ; tubercle of, 449
Mucoid degeneration, i. 176
Mucor, ii. 962 ; mucedo, 960
Müller's duct, ii. 929
Multiple neuritis, ii. 762
Mumps, ii. 457
Murmurs, anæmic, i. 654, 658 ; cardiac and vascular, 652 ; cardiac, direction, 657 ; causes, 656, ii. 53 ; dynamic, i. 656 ; endocardial, 653 ; exocardial, 652 ; functional, 654 ; harsh and grating, 659 ; musical, 658 ; organic, 653 ; respiratory, abnormal, ii. 55 ; vascular, i. 653
Muscarin, ii. 988
Muscle, colloid of, i. 175 ; hypertrophy, 165 ; inflamed, 243 ; in healing, 271 ; regeneration, 308
Muscles, atrophy of, ii. 755
Muscular exertion, i. 570
Musculi papillares, hypertrophy, i. 636
Museum preparations, i. 43
Mycetes, chemical actions, ii. 959 ; classification, 958
Mycetoma, ii. 1027
Mydalein, ii. 988
Mydatoxine, ii. 988
Mydine, ii. 988
Myelitis, ii. 582
Myocarditis, i. 244, 577, 589
Myocardium, diseases, i. 581
Myoma, i. 388 ; cardiac, 593
Myosin, i. 341
Myxo-cylindroma, i. 376
Myxœdema, ii. 771 ; treatment of, 773
Myxomatous degeneration, i. 176 ; sarcoma, 369

NAILS, favus of, ii. 903
Nares, ii. 1 ; bleeding from, 2 ; catarrh of, 1 ; fibrous polypus, 3 ; syphilitic disease, 4 ; tumours, 2
Necrosis of bone, ii. 824
Nematoda, ii. 1062
Nephritis, i. 705, ii. 265 ; chronic interstitial, 277
Nerve cells, ii. 586 ; diseases of, 575 ; Golgi's stain, i. 83
Nerve fibres, diseases of, ii. 576 ; Pal's stain, i. 82 ; Pal-Exner stain, 83
Nerves, regeneration, i. 309 ; of endocardium, 595 ; peripheral stain, 82
Nervous system, i. 218, ii. 567 ; anæmia and hyperæmia, 600 ; diseases of basal ganglia, 675 ; diseases of blood-vessels, 581 ; diseases of histological elements, 575 ; diseases of lymph-vessels, 581 ; hyaline condition of, 579 ; involution following destruction of peripheral parts, 734 ; plan of, 642 ; syphilitic affections of, 587 ; tumours of, 737 ; wax-like disease of, 580
Neumann's hæmatoblasts, i. 489
Neuridin, ii. 987
Neurin, ii. 987
Neuritis, ii. 761, 762
Neuroglia, ii. 585 ; diseases of, 576
Neuromata, i. 392 ; fibrous, 383
Neuro-retinitis, ii. 285
New formations, i. 359
Nipple in cancer, ii. 795 ; Paget's disease of, 803
Nitrates, reduction of, ii. 995 ; reduction of, by cleft-fungi, 966
Nitrogen, absorption of, by cleft-fungi, ii. 966 ; assimilation by moulds, 961 ; estimation of, 344 ; excretion of, by kidney, 339 ; free absorption of, 995, 996
Nodes, syphilitic, ii. 843
Noma of cheek, ii. 447 ; of labium majus, 421
Norris's corpuscle, i. 190
Nose, elephantiasis of, ii. 894
Note-taking, i. 37
Nurses, phthisical, i. 432
Nutritive artery of bone, ii. 813 ; gelatine, i. 114

OBLIGATORY parasites, ii. 958
Obliterative pneumonia, ii. 109
Occipital lobes, ii. 695
Occipito-parietal band, ii. 694
Odontoma, i. 388, ii. 867
Odour of organs, i. 35
Œdema, i. 328, 330, 339 ; of lung, 689, ii. 176
Œsophagismus, ii. 465
Œsophagus, ii. 461 ; action of corrosives, 464 ; dilatation, 463 ; examination of, i. 17 ; post-mortem digestion, ii. 464
Oidium, ii. 961
Oil and coagulation, i. 472
Old age, i. 705 ; pulse in, 714
Olfactory cortical centre, ii. 624
Oligæmia, i. 496
Oligocythæmia, i. 496
Olivary bodies, ii. 680
Omentum, examination, i. 217 ; inflamed, 227, 228, 239 ; inflamed, connective tissue proliferation, 241
Omphalo-mesenteric duct, ii. 913
Ophthalmoplegia, ii. 706
Optic nerve, connections of, ii. 687 ; effect of division of, 693
Optic neuritis, ii. 708 ; retina in, 712
Orchitis, ii. 374

Organisation, i. 267, 268; of thrombus, 302; of porous bodies, 287
Organisms, filtering, i. 132
Organs, colour, i. 34; consistence, 33; contour, 33; cut surface, 34; microscopic examination of, 36; odour, 35; in pernicious anæmia, 505; size, 32; squeezing and scraping, 35; surface and edges, 33; weight, 31
Ossification, ii. 811; points of, 814
Ossifying sarcoma, i. 368
Osteitis, ii. 826; deformans, 827
Osteoblasts, ii. 812
Osteoclasts, ii. 816
Osteoid-sarcoma, i. 368
Osteoma, i. 369, 387, ii. 805
Osteomalachia, ii. 836
Osteomyelitis, ii. 828
Osteophagi, ii. 816
Osteoporosis, ii. 816
Osteo-sarcoma, i. 368
Ovarian ascites, malignant cells in, ii. 437; dropsy, 429, 431
Ovary, ii. 428; cancer and sarcoma, 439; chondroma of, 439; cicatrices in, 429; cirrhosis of, 441; cystoma dermoideum, 438; cystoma glandulare, 433; cystoma myxoidea papillare, 434; development of, 930; displacements of, 441; inflammation of, 440; myoma of, 439; myxoid, dermoid, and papillary tumours, 431; results of ovulation, 428; structure, 428; tubercle of, 439
Oxaluria, ii. 334
Oxyuris vermicularis, ii. 1063
Ozæna, ii. 3
Ozonised air, i. 151

PACHYMENINGITIS, ii. 567; hæmorrhagica, 604
Paget's disease of nipple, ii. 803, 1052
Pain, i. 259; in hepatic disease, ii. 203
Painful subcutaneous tubercle, i. 390
Painting museum preparations, i. 53
Palato-schisis, ii. 917
Pal-Exner stain, i. 83
Palpitation, i. 568; influence of nerves, 568
Pal's stain, i. 82
Pancreas, ii. 560; cysts, 561; diseases of ducts, 561; examination of, i. 19; fat necrosis, ii. 561; inflammation of, 561; neoplasms, 562
Pancreatic diabetes, ii. 560
Papillæ, reconstruction, i. 278
Papillomata, i. 398
Paraffin, embedding in, i. 61
Paralbumin, i. 341
Paralysis, acute ascending, ii. 758; diphtheritic, 24; essential, 753; peripheral, 762; reflex, 759; spastic, 757; urinary, 759
Paramæcium, ii. 1055
Parametritis and perimetritis, ii. 409
Paranephritis, ii. 301
Paraphasia, ii. 667
Paraphimosis, ii. 384
Paraplegia, ataxic, ii. 750; urinary, 759
Parasites, ii. 958; animal, 1051
Parenchymatous inflammation, i. 260; nephritis, ii. 266
Paroophoron, ii. 931
Parosmia, ii. 5
Parotitis, acute infective, ii. 457
Parovarian cysts, ii. 424
Parovarium, ii. 931
Pasteur's fluid, i. 13; preventative inoculation, anthrax, 142; system of attenuation, 141
Pavy's method for separating sugar from blood, i. 524
Pawlowsky's apparatus, atmospheric germs, i. 154
Pectoriloquy, ii. 58
Pediculi, ii. 1082
Pedunculated hydatid, ii. 929; hydatid of Morgagni, 373
Pellagra, ii. 872
Pelvic hæmatocele, ii. 415, 426
Pemphigus, ii. 880
Penicillium glaucum, ii. 960
Penis, cancer, ii. 384
Pentastoma, ii. 1082
Peptonæmia, i. 470
Peptone, i. 511
Peptones, ii. 473, 474, 476, 483; fate of, 483; tests for, 321
Peptonuria, ii. 320
Peptotoxin, ii. 987
Percussion, normal, ii. 59; sounds, physical causes, 59; stroke, i. 701
Perforating ulcer, i. 317
Periarteriitis, i. 668; nodosa, 668
Pericarditis, i. 552; etiology, 555
Pericardium, adherent, i. 646; structure, 552; tumours, 556
Periosteitis, ii. 824
Periosteum, transplantation of, ii. 820
Peripheral paralysis, ii. 762
Perisplenitis, ii. 788
Peritoneum, ii. 562; cancer, 565; lipomata, 565; tuberculosis, 564
Peritonitis, i. 239, 241, 262, 705, ii. 562
Perityphlitis, ii. 554
Perlsucht, i. 432
Pernicious anæmia, i. 497, 502; etiology, 507
Perosmic acid stain, i. 89
Pertussis, ii. 8
Pettenkofer's test for bile acids, ii. 202
Phagocytes, i. 266, 293
Phagocytosis, ii. 241, 1004
Pharynx, ii. 461
Phenylacetic acid, i. 151
Phenylpropionic acid, i. 151
Phlebectasy, i. 692

Phlebitis, i. 691
Phleboliths, ii. 425
Phonometry, ii. 60
Phosphaturia, ii. 329
Phosphorous poisoning, i. 585, ii. 234
Photogenous organisms, ii. 976
Photography, i. 111
Phthisis and cancer, ii. 154; contagiosity, 154; etiology, 151; from hæmorrhage, 153; and heart disease, 154; and pregnancy, accouchement, lactation, etc., 153; pulmonary, i. 645, ii. 130, 135, 144; pulmonary, absence of fœtid odour, 145; pulmonary, healing of cavities, 144
Piarrhæmia, i. 530
Picro-carmine, i. 78
Picro-lithium-carmine, i. 78
Pigment, ii. 322, 974; of cleft-fungi, conditions of secretion, 975; extraneous, i. 179; inhaled, 179
Pigmentation, i. 177, 587; in Addison's disease, ii. 781, 782; spurious, 868
Pig typhoid, ii. 530
Pineal gland, adenomata, ii. 739
Pituitary body, double, ii. 945
Pityriasis rubra, ii. 868; versicolor, 906
Placenta, diseases of, ii. 949; as a filter, 1046; infarcts of, 950; inflammation of, 952; syphilitic, 952
Plasmodia of malaria, ii. 1056
Pleomorphism, ii. 959
Plethora, i. 465, 466
Plethysmograph, i. 695
Pleura, ii. 32; gas in, 168; perforation of, 166, 170; tubercle, 36; tumours, 36
Pleurisy, i. 236, ii. 32; and tuberculosis, 36
Pleuro-pneumonia of cattle, ii. 102, 111; microbe of, 114; of oxen, i. 236
Plexiform angeiomata, i. 393
Pneumaturia, ii. 328
Pneumobacillus, ii. 106; liquefaciens bovis, 114
Pneumococcus, i. 605, ii. 106; staining of, i. 138
Pneumogastrics, i. 527
Pneumograph, Marey's, ii. 42
Pneumokonioses, ii. 91
Pneumonomycosis aspergillina, ii. 962
Pneumonia, i. 705; acute catarrhal, ii. 119; anthracoid, 1040; of cattle, 102, 111; chronic interstitial, 138; croupous, 102; obliterative, 109; suppurative interstitial, 117; tubercular, 129; vagus, 110; wandering, 110
Pneumopericardium, i. 557
Pneumothorax, ii. 166
Poikilocytes, i. 163
Poisons, interception of, ii. 189
Polarisation, i. 340
Poliomyelitis anterior, ii. 753; anterior chronica, 754
Polydactylism, ii. 946
Polydipsia, ii. 327
Polymastia, ii. 794
Polypi, i. 411; channel, 413; mucous, 411; muscular, 413; sarcomatous, 413
Polypus of urethra, ii. 370
Polythelia, ii. 794
Polyuria, ii. 327
Pompholyx, ii. 879
Pons, diseases of, ii. 678; hæmorrhage into, 678
Porencephalia, ii. 581
Portal vein, constriction, i. 528; thrombosis, 675
Post-nasal adenoid growths, ii. 456
Potash salts, i. 550
Potato paste, i. 119; sterile, 119
Potter's lung, ii. 98
Pouchet's apparatus, atmospheric germs, i. 156
Predicrotic wave, i. 701
Prefrontal region, effect of lesions of, ii. 622
Pregnancy, i. 467, 705; extra-uterine, ii. 412; and heart disease, i. 650; multiple, ii. 940; ovarian, 416; peritoneal, 416
Preparations, museum—brain, i. 45; glycerine jelly for, 44; hand, 43; ophthalmic, 45
Prepuce, ii. 383
Preservative fluid, i. 70
Pressure, arterial, i. 694
Preyer, hæmoglobin, i. 451
Prickle cells, i. 357
Primary lateral sclerosis, ii. 757
Proctodæum, ii. 933
Propeptonuria, ii. 321
Prophylaxis, i. 147
Proscolex, ii. 1072
Prostate, ii. 382; calculi, 338
Proteids, digestion of, ii. 473; dropsical liquids, i. 341, 342
Proteolytic ferments, ii. 979
Proteoses, ii. 474
Proteus, ii. 984
Protozoa, ii. 1051
Prurigo, ii. 889
Psammoma, i. 379, ii. 738
Pseudo-tuberculosis, i. 437
Psoriasis, ii. 881; buccal, 448
Psorospermia, ii. 804, 1052
Ptomaines, i. 550, ii. 975, 985, 986; table of, 990
Pudendal hæmatocele, ii. 421
Pudendum, diseases of, ii. 420
Pulex, ii. 1082
Pulmonary artery, valve, i. 614; [illegible], 323
Pulmonary tuberculosis, contagiosity, ii. 154; death, 158; spread of, 145; treatment, 155
Pulse, i. 696, 705, ii. 191; in aneurism, i. 713; in arteritis, 713; in asthma, 713; Corrigan's, 712; dicrotic, 709; of high

pressure, 705 ; of low pressure, 709 ; in maniacs, 714 ; monocrotic, 711 ; in old age, 714 ; rapidity in disease, 699 ; tricrotic, 711 ; in valvular disease, 711 ; varieties, 698 ; water-hammer, 712 ; wave, 696
Pupil reflexes, ii. 704
Purpura, i. 545 ; hæmorrhagica, 470
Pus, i. 262 ; formation of, 242 ; methods of examining, 264
Putrefaction, i. 183, ii. 960, 983 ; organisms of, 983
Putrescine, ii. 987, 988
Pyæmia, i. 677, ii. 1017
Pyæmic abscess, i. 602
Pyelo-nephritis, ii. 298
Pygopagus, ii. 945
Pyocyanin, ii. 975
Pyogenic organisms in Man, ii. 1015 ; source, 1016
Pyothorax, ii. 35
Pyramidal fibres, ii. 652

QUININE, i. 233

RAG-PICKERS' disease, ii. 1041
Rainey's capsules, ii. 1052
Ranula, ii. 457 ; of pancreas, 561
Raynaud's disease, ii. 763
Reagents, microscopic, i. 77 ; staining, 77
Red hepatisation, ii. 103 ; softening, 587 ; zone, i. 681
Redness of inflammation, i. 260
Reduction of nitrates, ii. 995
Reflex paralysis, ii. 759
Regeneration of tissues, i. 307
Relapsing fever, ii. 1047, 1104
Remak's ganglion, i. 563
Renal inadequacy, ii. 327
Reports, i. 37, 41
Respiration, i. 696 ; influence of brain tracts, ii. 49 ; influence of superior and inferior laryngeals, 48 ; influence of vagus, 48 ; inspiratory and expiratory centres, 47 ; movements, 42
Respirarory bundle, ii. 46 ; centres, 44 ; murmur, normal, 52 ; murmurs, abnormal, 55 ; murmurs, cause, 53 ; muscles, automatism, 47 ; sounds, physical causes, 52 ; volume, 49
Retentive power of abdomen, ii. 407
Retinitis, ii. 285
Rhabdomyoma, i. 390
Rheumatic gout, i. 535
Rheumatism, i. 535 ; theories, 537
Rhinoscleroma, ii. 895
Rhizopoda, ii. 1051
Rhonchi, ii. 56
Ricin, immunity, ii. 1002
Rickets, ii. 830 ; fœtal, 835
Rigidity after cerebral hæmorrhage, ii. 677
Ringworm, ii. 904
Roaring, ii. 8
Rodent ulcer, i. 408
Rose, ii. 873
Roseola, ii. 872
Rumination, ii. 500
Runeberg's experiments on filtration, i. 322
Rupia, ii. 885
Russell's fuchsin bodies, ii. 1055

SACCULAR aneurism, i. 670
Sago spleen, ii. 785
Salicylic acid, i. 233
Saliva, influence in digestion, ii. 469
Salivary concretions, ii. 459 ; fistula, 459 ; gland, cancer, i. 405 ; glands, ii. 456 ; glands, tumours, 458
Salpingitis, ii. 411
Salt frog, i. 253
Salt solution, i. 472
Sanderson's system of attenuation, i. 143
Sapræmia, ii. 1020
Saprin, ii. 987
Saprophytes, ii. 958
Sarcina, ii. 964, 1048 ; lutea, 974
Sarcoma of lung, ii. 176 ; of mamma, 796
Sarcomata, i. 359 ; alveolar, 371 ; of bone, 368 ; degenerations, 380 ; embryonic significance, 360 ; giant-cell, 366 ; lipomatous, 378 ; melanotic, 370 ; myxomatous, 369 ; oat-seed-like, 365 ; round cell, 361 ; spindle-cell, 363 ; spindle-cell, reproduction, 365
Scalds, duodenal ulcer after, ii. 520
Scarlatina, ii. 1103
Scarlet fever, ii. 910 ; kidney, 291
Schäfer, reaction of blood, i. 450
Scheuerlen's bacillus, i. 407
Schistoprosopia, ii. 918
Schizomycetes, ii. 964
Sciatic, division of, i. 220 ; nerve, 328
Scleroderma, ii. 892
Sclerosis, ii. 576 ; diffuse, 577 ; insular, 578 ; insular or disseminated, 742 ; primary lateral, 757 ; systemic, 577
Scolex, ii. 1073
Scoliosis, ii. 865
Scrofula, i. 436
Scrotum, ii. 383
Scurvy, i. 547 ; stomatitis of, ii. 447
Scutula, ii. 903
Sebaceous glands, diseases of, ii. 886
Seborrhœa, ii. 886
Secondary degeneration, ii. 714 ; ascending, 725 ; bilateral, 717 ; descending, 724 ; destination of ascending tracts, 727 ; distance to which the tracts descend, 723 ; from lesions of cord, 723 ; in nerve trunks, 714 ; periods in, 719 ; of posterior nerve root, 730 ; progressive alteration, 729 ; structural alterations, 728 ; at various levels, 719
Sectio cadaveris, i. 1 ; aorta, 19 ; bladder, 17 ; brain, 20 ; external appearances, 4 ; first incision, 5 ; general examination of

organs, 31 ; head, 20 ; heart, 6 ; instruments, 2 ; kidneys, 15 ; liver, 14 ; lungs, 14 ; lymphatic glands, 19 ; measurement of liquids, 5 ; mouth, larynx, and pharynx, 19 ; œsophagus, 17 ; pancreas, 19 ; reagents, 4 ; semilunar ganglia, 19 ; spinal cord, 29 ; spleen, 15 ; stomach and intestines, 17 ; supra-renal capsules, 17 ; typhoid, 19 ; ureters, 16 ; vena cava, 19
Section-cutting, i. 62 ; preparation for, 58 ; serial, 68 ; serial, Weigert, 69
Sections through brain, i. 23
Segmental duct, ii. 929
Semicircular canals, ii. 680
Semilunar ganglia, examination, i. 19
Senftleben experiment, i. 304
Septic abscess, i. 677 ; emboli, 677
Septicæmia, ii. 1018 ; hæmorrhagica, 1019 ; of mice, 1018 ; of rabbits, 1019
Serum, antitoxic, ii. 999 ; in coagulation of blood, i. 302 ; germicidal, ii. 1001
Serum-steriliser, i. 117
Sex, i. 467
Sheep, Algerian, immunity of, ii. 997
Shock, i. 471
Sibilant sounds, ii. 56
Siderosis, ii. 101
Silicosis, ii. 97
Silver, stain, i. 88 ; stained cornea, 249
Simple histioid tumours, i. 381
Sinuses, ii. 854 ; cerebral, thrombosis of, 581
Situs transversus, ii. 946
Skin, ii. 868 ; cancer, i. 406 ; inunction and albuminaria, ii. 315 ; œdema, i. 328 ; pigmentation of, ii. 781 ; pigmented, 868 ; vesicular diseases of, 879
Skin-grafting, i. 277, 307
Smallpox, ii. 910
Small red granular kidney, ii. 277
Snake-poison, ii. 985
Sneezing, ii. 70
Snoring, ii. 70
Soft chancre, i. 317
Soil as harbourer of pathogenic organisms, ii. 977
Soot, inhalation of in phthisis, ii. 156
Sounds of heart, prolongation, i. 659
Spanæmia, i. 496
Spasmotoxine, ii. 988
Spastic paralysis, ii. 757
Spectroscope and hemoglobin, ii. 324
Speech, physical basis of, ii. 657
Spermatocele, ii. 373
Sphygmogram, and blood-pressure, i. 697 ; normal, 701 ; in old persons, 702
Sphygmograph, i. 700
Sphygmotonometer, i. 696
Spina bifida, i. 336
Spinal cord, circulation within, ii. 590 ; examination, i. 29 ; and excessive atmospheric pressure, ii. 598 ; hemorrhage into, 603 ; section, i. 527 ; tracts in, ii. 715
Spine, curvature of, ii. 865
Spirillum, ii. 964 ; choleræ Asiaticæ, 975
Spirochæta, ii. 964 ; Obermeieri, 1047
Spirometer, Hutchinson's, ii. 50
Splashing sound, ii. 57
Spleen, i. 417, 619, ii. 784 ; of ague, 789 ; as blood-transforming organ, i. 485 ; examination of, 15 ; infarction, 681 ; in jaundice, ii. 192 ; in leucocythæmia, i. 513 ; pernicious anæmia, 506 ; sinuses of, ii. 787 ; syphilitic, 788 ; thickening of capsule, 788 ; tubercle of, 788 ; tumours of, 789 ; typhoid, 790 ; venous engorgement, 785 ; wax-like, 785
Splenic, artery, i. 486 ; fever, ii. 1042 ; vein, i. 485
Splenification, ii. 167
Splenotomy, i. 487
Spondyl-olisthesis, ii. 866
Sponge, organisation, i. 287 ; siliceous, 294
Spores, endogenous, ii. 967
Sporozoaria, ii. 1052
Sprue, ii. 538
Sputum, bronchiectasy, ii. 89 ; bronchitis, 83 ; croupous pneumonia, 106 ; phthisical, i. 432 ; in pulmonary tuberculosis, ii. 145 ; staining of, i. 139
Squibb's method for estimating urea, ii. 343
Stagnation, inflammation, cause, i. 231
Staining, double, bacteria, i. 134 ; of bacteria, 133 ; reagents, 77
Stammering, ii. 658, 673
St. Anthony's Fire, ii. 873
Staphylococcus, ii. 1010 ; pyogenes albus, 1012 ; pyogenes aureus, i. 605, ii. 829, 974, 988, 1010
Starch, action of saliva on, ii. 469 ; fermentation of, 981
Statistics on endocarditis, i. 595
Steam, sterilisation by, i. 122
Sterilisation, i. 122
Stethometer, Sanderson's, ii. 43
Stethoscope, ii. 53
Stimulants, action on wounds, i. 285
Stings, i. 332
Stomach, ii. 466 ; acids of, analyses, 492 ; acids of, tests for, 494 ; acute perforating ulcer, 507 ; cancer, 510 ; catarrh, 505 ; dilatation, 503 ; diphtheritic, 509 ; examination of, i. 17 ; fasting, ii. 468 ; follicular ulceration, 507 ; functional diseases, 487 ; organic diseases, 503 ; organic disease and detection of hydrochloric acid, 511 ; polypi, myomata, sarcomata, 513 ; post-mortem digestion, 506 ; secretions of, 471 ; state at various periods of digestion, 477 ; stenosis of pylorus, 512 ; structure and functions, 466 ; tubercle, 513
Stomatitis, ii. 446
Strangury, ii. 358

Streptococcus, ii. 1010 ; pyogenes, i. 605, ii. 829, 1012 ; pyogenes albus, 829
Streptothrix of Eppinger, ii. 975
Stricture of urethra, ii. 370
Strobila, ii. 1073
Stroma of cancers, i. 402
Strongylus duodenalis, ii. 1063
Struma, ii. 776
Succinic acid, i. 511
Suctorial worms, ii. 1068
Sudamina, ii. 879
Sugar in blood, i. 523 ; in diabetic blood, 525 ; generation of, from proteids, ii. 188 ; history of, i. 520 ; history of, in stomach, ii. 478
Sulphur grains, ii. 965
Sunlight, influence on cleft-fungi, ii. 974
Superfœtation, ii. 940
Suppuration, i. 242, 262 ; causes, 262 ; of cornea, 253 ; definition, 262 ; and organisms, ii. 1016 ; organisms of, 856, 1010 ; organisms, disinfection, i. 151 ; and peptonuria, ii. 320
Supra-renal capsules, ii. 780 ; examination of, i. 17 ; hypertrophy of, ii. 783 ; removal of, 780 ; supernumerary, 783 ; tumours of, 783
Swelling, inflammatory, i. 260
Sympathetic, pernicious anæmia, i. 506
Symptomatic anthrax, ii. 1046
Synophthalmia, ii. 923
Syntonin, ii. 473
Syphilis, i. 592, ii. 285, 910 ; of bone, 843 ; of larynx, 30 ; of lung, 172 ; of membranes of brain, 568 ; of nares, 4 ; of placenta, 952 ; of teeth, 867 ; of testicle, 376 ; and tract lesions, 587
Syphilitic bacillus, i. 440 ; liver, ii. 236 ; stain, i. 137
Syringomyelia, i. 336

TACTILE sensibility, centres for, ii. 621
Tadpole's tail, i. 216
Tænia, echinococcus, ii. 1076 ; mediocanellata, 1074 ; solium, 1072
Tail, fish, i. 217 ; tadpole's, 216
Talipes, ii. 946
Teeth, diseases of, ii. 866
Telangiectatic angeiomata, i. 393
Temperature, i. 259, 473, 691 ; of animals, ii. 1089 ; of body and that of surroundings, 1090 ; and croupous pneumonia, 108 ; equilibrium of, 1093 ; normal, 1087 ; regulation of, by nervous system, 1094 ; rhythm, 1089
Tendon, regeneration, i. 308
Teratoma, ii. 945
Testicles, ii. 371 ; atrophy and hypertrophy, 372 ; cysts of, 373 ; development of, 930 ; inflammation of, 374 ; neoplasms of, 379 ; sinuses, 379 ; supernumerary, 371 ; syphilitic, 376 ; tubercular, 377
Test papers, Oliver's, ii. 320
Tetanine, ii. 988
Tetanotoxine, ii. 988
Tetanus, ii. 988, 1035 ; vaccination against, 998
Thalamus opticus, ii. 675
Thermometry, surface, ii. 1098
Thermo-regulators, i. 130
Third ventricle, gray matter of, ii. 681
Thomsen's disease, ii. 756
Thoracic duct, ligature, i. 326
Thoraco-gastro-schisis, ii. 914
Thoracopagus, ii. 943 ; parasiticus, 944
Thrombi, cardiac, i. 622 ; septic, 602
Thrombosis, i. 300, 302, 675, ii. 761
Thrombus, white, i. 300
Thrush, ii. 446
Thymol, i. 149
Thymus in exophthalmic goitre, ii. 779
Thyroid, ii. 769 ; as blood-transforming organ, i. 493 ; removal of, ii. 770 ; supernumerary, 776 ; transplantation of, 771 ; tumours of, 779
Tidal wave, i. 701, 703
Tissue, attraction theory, i. 233 ; counterpoise, 280
Tissues, elasticity of, i. 281 ; preparation of, for staining, 139 ; regeneration, 307
Tobacco and tea, i. 572
Tongue, ii. 443, 448 ; acute inflammation, 448 ; angeiomata, 449 ; annulus migrans, 451 ; black-hair, 449 ; cancer and sarcoma, 450 ; enlargement of follicular glands, 449 ; frog's, i. 215, 225 ; as an index of disease, ii. 451 ; nervous affections, 453 ; pigmented, 449 ; pityriasis of, 451 ; syphilitic, 450
Tonic function, visceral muscles, i. 632
Tonsils, diseases of, ii. 454
Tophi, i. 543
Topography, cranial, ii. 611
Tox-albumins, ii. 993
Trachea, functional diseases, ii. 6
Tracheal injections, ii. 157
Transfusion, i. 473 ; of milk, 206
Transplantation, fœtal tissues, i. 311
Transudates, coagulation, i. 340 ; composition, 340
Transudations, i. 319, 330
Trematoda, ii. 1068
Tricephalus, ii. 946
Trichina spiralis, ii. 1064
Trichinæ, i. 332
Trichocephalus dispar, ii. 1063
Trichomonas vaginalis, ii. 1055
Trichosis vesicæ, ii. 363
Tricrotic pulse, i. 711
Tricuspid, disease, i. 626, 643 ; valve, 613, 615
Trophic centres, for ascending fibres in cord, ii. 727 ; for peripheral nerves, 715
True aneurism, i. 670
Tryptonæmia, i. 470
Tube-casts, ii. 349

Tubercle, i. 417, ii. 989, 910; and age, 151; and constitution, 152; contagiosity, i. 431; degenerations, 427; and fœtus, ii. 153; glandular complication, i. 429; and growth, ii. 151; and heredity, 152; inhalation, i. 434; and insanity, ii. 153; of joints, 846; of larynx, 28; liability of animals to, i. 430; of lung, interstitial, ii. 140; of lung, vascular, 147; means of contamination, i. 431; and menstruation, ii. 153; and mortality, 152; from non-tubercular infection, i. 435; and scrofula, 436; seats, 421; and sex, ii. 152; and stature, 151; structure, i. 422
Tubercle bacillus, i. 419, 434, 605, ii. 131, 135, 144; Ehrlich-Weigert stain, i. 135; Fütterer's stain, 137; Gibbes' stain, 137; Koch's stain, 135; staining, 135; Ziehl-Neelsen stain, 136
Tubercular lung, absence of fœtid odour, ii. 145; sputum, 145
Tubercular pneumonia, ii. 129; absence of fœtid odour, 145; cirrhosis in, 138; disseminated, 146; healing of cavities, 144; organs in, 146; spread of, 145; sputum in, 145; stages, 129; vessels in, 138
Tuberculin, ii. 157, 989, 1087
Tuberculosis, artificial, i. 429; bronchial, ii. 90; genital, 410; and ingesta, i. 432; pulmonary, ii. 129; temperature in, 1104
Tubes, circulation through, i. 196
Tubular breathing, ii. 55
Tumours, i. 359; of brain, ii. 737; classification, i. 442; examination of, 441; of heart, 593; simple histioid, 381
Tympanitic sound, ii. 59
Typhlitis, ii. 554
Typhoid, i. 18, 19, ii. 988, 1103; bacillus of, 527, 1014; bacillus, staining of, i. 138; fever, ii. 522; larynx in, 28; of pig, 530; spleen, 790
Typhus, ii. 1103
Tyrosin, i. 511, ii. 345

UDDER, tubercular, i. 433
Ulcer, acute perforating, of œsophagus, ii. 461; cancerous, i. 317; chancrous, 315, 317; constitutional, 315; diphtheritic, 318; indolent, 294, 313; inflamed, 315; perforating, 317; rodent, 318, 408; sloughing, 315; syphilitic, 315; tubercular, 318; varicose, 315; weak, 314
Ulceration, i. 313
Umbilical vesicle, ii. 913
Urachus cyst, ii. 914
Uræmia, i. 548; theories, 549
Urates, ii. 347
Urea, i. 540, 549, ii. 339; and bile secretion, 187; formation of, 186; qualitative and quantitative analysis of, 341; and temperature, 187
Ureters, diseases of, ii. 364; examination of, i. 16; obstruction, 338; tubercular, ii. 305
Urethra, chancres of, ii. 370; diseases of, 367; polypi, 370; stricture, 370
Urethral caruncle, ii. 421
Uric acid, i. 539, ii. 346; detection, i. 543; estimation of, ii. 347
Urinary calculi, ii. 336; deposits, organised, 348; paraplegia, 759
Urination, physiology of, ii. 354
Urine, i. 506, ii. 311; accidental impurities, 351; alkalinity of, 329; in catarrhal nephritis, 272; in cirrhotic kidney, 285; colouring matter of, 335; colouring matter and drugs, 335; and diet, 339; in diphtheria, 27; estimation of solids, 263; and hæmolysis, 323; quantity in health, 327; quantity in polyuria, 328; in wax-like kidney, 277
Urobacillus liquefaciens septicus, ii. 1015
Urobilin, ii. 193, 335
Urochrome, ii. 335
Uro-genital sinus, ii. 933
Urticaria, ii. 873
Uterus, ii. 385; absorption of myomata of, 399; cancer of, 401; displacements of, 404; erosion of cervix, 398; hæmorrhage from, 400; hernia of, 408; immersion of, 408; myo-carcinoma of, 401; polypi of, 402; prolapse of, 409; smooth myoma, 399; striated myoma, 401; structure and functions, 385; tumours, 399; versions and flexions, 407; villous, 393

VACCINATION, ii. 997; chemical, 998; against cholera, 1001; with the microbe, 998
Vaccines, ii. 997
Vacher's apparatus, testing air, i. 155
Vacuolation, i. 254
Vagina, ii. 418; cysts, 419; inflammation of, 418; tumours, 419; ulceration, 419
Vaginal hydrocele, ii. 420
Vaginismus, ii. 421
Vagus pneumonia, ii. 110
Valves of heart, effects of endocarditis on, i. 610; entrance of organisms, 606; malformation, 620, 621; rupture, 620; testing, 9
Valvular disease of heart, i. 500; and blood-pressure, 618; and cirrhotic kidney, ii. 285; danger of, i. 617; effects on other organs, 619; pulse in, 711
Varicocele, ii. 380
Varicose aneurism, i. 670
Variola, ii. 1104
Varix, i. 692; of pelvic veins, ii. 425
Vaso-constrictors, i. 660
Vasocorona of spinal cord, ii. 591
Vaso-dilators, i. 660
Vaso-motor nerves of lung, ii. 49

Vegetations, i. 598, 602, 608, 613
Vein, liquid, i. 656
Veins, i. 660 ; inflammatory affections of, 691
Venereal warts, i. 399
Venesection, i. 463, 486
Venous obstruction, i. 324, 326
Ventricles of heart, dilatation, i. 621
Vermes, ii. 1062
Vernix caseosa, ii. 886
Vertebræ, tuberculosis of, ii. 854
Vertigo, ii. 501
Vesicles, formation of, ii. 881
Vesico-vaginal fistula, ii. 361
Vesiculæ seminales, tubercular, ii. 305
Vessels, of endocardium, i. 594 ; relation to amyloid, 169
Vibrio, ii. 964
Virchow's attraction theory, i. 233
Viscera in leucocythæmia, i. 513
Visceral clefts, ii. 916
Visual cortical centre, ii. 624
Vital capacity, ii. 50
Voice sounds, physical causes, ii. 57
Volvulus, ii. 535
Vomiting, ii. 500

WANDERING pneumonia, ii. 110
Warts, i. 398 ; venereal, ii. 384
Wasting palsy, ii. 754
Water, bacteriological investigation of, i. 157
Water-brash, ii. 499
Water-hammer-pulse, i. 612
Wax-like disease, i. 167, 589, ii. 146 ; of arteries, i. 674 ; of brain, ii. 580
Wax-like kidney, dropsy in, ii. 277 ; terminations, 277 ; urine in, 277 ; varieties, 273
Wax-like liver, ii. 229
Web, frog's, i. 214
Weigert's hæmatoxylene stain, i. 80
Weil's disease, ii. 200
Wens, ii. 886
Whip-worm, ii. 1063
Whispering sounds, ii. 58
White swelling, ii. 849, 851
Whooping-cough, ii. 8, 69
Wolffian duct, ii. 929
Woolsorter's disease, ii. 1040
Word-blindness, ii. 668
Word-deafness, ii. 668
Worms, round, ii. 1062 ; suctorial, 1068

XANTHELASMA, ii. 190
Xanthin, ii. 348
Xanthopsy, ii. 190
Xeroderma, ii. 883
Xylol balsam, i. 95

YEAST, ii. 963 ; composition, 963 ; conditions of growth, 963 ; fermenting function, 964 ; nourishment, 963 ; rose-coloured, 974

ZINC cement, i. 96
Zooglœa masses, ii. 965
Zopf's classification of schizomycetes, ii. 959

THE END

Printed by R. & R. CLARK, *Edinburgh*.

BOOKS ON PATHOLOGY AND MEDICINE.

A TEXT-BOOK OF PATHOLOGY, SYSTEMATIC AND PRACTICAL. By Professor D. J. **Hamilton**, M.B., F.R.C.S.E., F.R.S.E. With numerous Illustrations. Vol. I. Medium 8vo. 25s.

ON THE PATHOLOGY OF BRONCHITIS, CATARRHAL PNEUMONIA, TUBERCLE, AND ALLIED LESIONS OF THE HUMAN LUNG. By the same Author. 8vo. 8s. 6d.

A TEXT-BOOK OF PATHOLOGICAL ANATOMY AND PATHOGENESIS. By **Ernst Ziegler**, Professor of Pathological Anatomy in the University of Tübingen. Translated and edited for English students by **Donald MacAlister**, M.D., F.R.S.

Part I. General Pathological Anatomy. Second Edition. Med. 8vo. 12s. 6d.

Part II. Special Pathological Anatomy. Sections I.-VIII. Med. 8vo. 12s. 6d.

Part II. Special Pathological Anatomy. Sections IX.-XII. Med. 8vo. 12s. 6d.

METHODS OF PATHOLOGICAL HISTOLOGY. By C. **von Kahlden**, Assistant Professor in the University of Freiburg. Translated and edited by H. **Morley Fletcher**, M.A., M.D. With an Introduction by G. **Sims Woodhead**, M.D. 8vo. 6s.

⁂ *A Companion Volume to Ziegler's "Pathological Anatomy."*

A COURSE OF ELEMENTARY PRACTICAL HISTOLOGY. By **William Fearnley**. Crown 8vo. 7s. 6d.

By T. LAUDER BRUNTON, M.D., F.R.S.

A TEXT-BOOK OF PHARMACOLOGY, THERAPEUTICS, AND MATERIA MEDICA. Adapted to the United States Pharmacopœia by F. H. **Williams**, M.D., Boston, Mass. Third Edition, containing the additions, 1891, to the British Pharmacopœia. 8vo. 21s. In 2 vols., 22s. 6d. Supplement separately, 1s.

TABLES OF MATERIA MEDICA, a Companion to the Materia Medica Museum. New Edition. 8vo. 5s.

PHARMACOLOGY AND THERAPEUTICS: or, Medicine, Past and Present. The Goulstonian Lectures delivered before the Royal College of Physicians in 1877. Crown 8vo. 6s.

AN INTRODUCTION TO MODERN THERAPEUTICS. Being the Croonian Lectures on the Relationship between Chemical Structure and Physiological Action in relation to the Prevention, Control, and Cure of Disease. Delivered before the Royal College of Physicians in London, June 1889. 8vo. 3s. 6d. net.

ON DISORDERS OF DIGESTION, THEIR CONSEQUENCES AND TREATMENT. 8vo. 10s. 6d.

THE CORRELATION OF STRUCTURE, ACTION, AND THOUGHT. Inaugural Address delivered at the Royal Medical Society of Edinburgh, on October 21, 1892. With Coloured Plate after Raphael. Reprinted from *The Lancet*. 8vo, sewed. 1s.

MACMILLAN AND CO., LONDON.

BOOKS ON MEDICINE AND PUBLIC HEALTH.

THE PRACTITIONER'S HANDBOOK OF TREATMENT; or the Principles of Therapeutics. By J. Milner Fothergill, M.D., late Physician to the Victoria Park Hospital. Third Edition. 8vo. 16s.

THE ANTAGONISM OF THERAPEUTIC AGENTS, and What it Teaches. By the same Author. Crown 8vo. 6s.

FOOD FOR THE INVALID, CONVALESCENT, THE DYSPEPTIC, AND THE GOUTY. By the same Author. 3s. 6d.

PHARMACOGRAPHIA: A History of the Principal Drugs of Vegetable Origin met with in Great Britain and India. By F. A. Flückiger, M.D., and D. Hanbury, F.R.S. Second Edition. Medium 8vo. 21s.

LESSONS ON PRESCRIPTIONS AND THE ART OF PRESCRIBING. By W. H. .Griffiths, Ph.D., L.R.C.P.E. New Edition, adapted to the Pharmacopœia 1885. Post 8vo. 3s. 6d.

HANDBOOK OF PUBLIC HEALTH AND DEMOGRAPHY. By Edward F. Willoughby, M.B., Diploma in State Medicine of the London University, and in Public Health of Cambridge University. Fcap. 8vo. 4s. 6d.

A MANUAL OF PUBLIC HEALTH. By A. Wynter Blyth, M.R.C.S. 8vo. 17s. net.

LECTURES ON SANITARY LAW. By the same Author. 8vo. 8s. 6d. net.

THE TREATMENT AND UTILISATION OF SEWAGE. By W. H. Corfield, M.A., M.D., F.R.C.P. Third Edition. Revised and enlarged by the Author and Louis C. Parkes, M.D. 8vo. 16s.

MACMILLAN AND CO., LONDON.

BOOKS ON ANATOMY AND PHYSIOLOGY.

A TEXT-BOOK OF COMPARATIVE ANATOMY. By Prof. ARNOLD LANG. With Preface to the English Translation by Prof. Dr. ERNST HAECKEL. Translated into English by HENRY M. BERNARD, M.A. Cantab., and MATILDA BERNARD. Vol. I. 8vo. 17s. net. [*Vol. II. in the Press.*

LESSONS IN ELEMENTARY ANATOMY. By ST. GEORGE MIVART, F.R.S., Author of "The Genesis of Species." Fcap. 8vo. 6s. 6d.

ELEMENTS OF THE COMPARATIVE ANATOMY OF VERTEBRATES. Adapted from the German of Prof. ROBERT WIEDERSHEIM. By W. NEWTON PARKER, Professor of Biology in the University College of South Wales and Monmouthshire. With additions by the Author and Translator. 270 Woodcuts. Medium 8vo. 12s. 6d.

A COURSE OF INSTRUCTION IN ZOOTOMY. Vertebrata. By T. JEFFERY PARKER, F.R.S., Professor of Biology in the University of Otago, New Zealand. With Illustrations. Crown 8vo. 8s. 6d.

AN INTRODUCTION TO THE OSTEOLOGY OF THE MAMMALIA: being the Substance of the Course of Lectures delivered at the Royal College of Surgeons of England in 1870. By Sir WILLIAM HENRY FLOWER, F.R.S. Illustrated. Third Edition. Revised with the assistance of HANS GADOW, Ph.D. Crown 8vo. 10s. 6d.

THE MYOLOGY OF THE RAVEN (*Corvus corax Sinuatus*). A Guide to the Study of the Muscular System in Birds. By R. W. SHUFELDT, of the Smithsonian Institute, Washington, U.S.A. With Illustrations. 8vo. 13s. net.

A TEXT-BOOK OF PHYSIOLOGY. By MICHAEL FOSTER, M.D., F.R.S., Professor of Physiology in the University of Cambridge, and Fellow of Trinity College, Cambridge. Illustrated. 8vo.

Part I. Comprising Book I. Blood—The Tissues of Movement, the Vascular Mechanism. Sixth Edition. 10s. 6d.

Part II. Comprising Book II. The Tissues of Chemical Action, with their Respective Mechanisms—Nutrition. Sixth Edition. 10s. 6d.

Part III. The Central Nervous System. Sixth Edition. 7s. 6d.

Part IV. Comprising the remainder of Book III. The Senses and some Special Muscular Mechanisms; and Book IV. The Tissues and Mechanism of Reproduction. Fifth Edition. 10s. 6d.

THE CHEMICAL BASIS OF THE ANIMAL BODY. An Appendix to Foster's "Text-Book of Physiology." By A. SHERIDAN LEA, M.A., D.Sc., F.R.S., University Lecturer in Physiology in the University of Cambridge. Fifth Edition. 8vo. 7s. 6d.

PHYSIOLOGY. By MICHAEL FOSTER, M.D., F.R.S. With Illustrations. Pott 8vo. 1s. [*Science Primers.*

MACMILLAN AND CO., LONDON.

BOOKS ON PHYSIOLOGY AND EMBRYOLOGY.

A COURSE OF ELEMENTARY PRACTICAL PHYSIOLOGY AND HISTOLOGY. By Prof. MICHAEL FOSTER, M.D., F.R.S., and J. N. LANGLEY, F.R.S., Fellow of Trinity College, Cambridge. Sixth Edition. Crown 8vo. 7s. 6d.

LESSONS IN ELEMENTARY PHYSIOLOGY. By T. H. HUXLEY, F.R.S. With numerous Illustrations. Fourth Edition. Pott 8vo. 4s. 6d.

QUESTIONS ON HUXLEY'S LESSONS IN ELEMENTARY PHYSIOLOGY. For the Use of Schools. By THOMAS ALCOCK, M.D. Fifth Edition. Pott 8vo. 1s. 6d.

A TEXT-BOOK OF THE PHYSIOLOGICAL CHEMISTRY OF THE ANIMAL BODY. Including an Account of the Chemical Changes occurring in Disease. By ARTHUR GAMGEE, M.D., F.R.S., Emeritus Professor of Physiology in the Owens College, Victoria University, Manchester, etc. 8vo. Vol. I. 18s. Vol. II. 18s.

A TREATISE ON COMPARATIVE EMBRYOLOGY. By F. M. BALFOUR, M.A., F.R.S., Fellow and Lecturer of Trinity College. Cambridge. In two Vols. Second Edition. Medium 8vo. Vol. I. 18s. Vol. II. 21s.

THE ELEMENTS OF EMBRYOLOGY. By Prof. MICHAEL FOSTER, M.D., F.R.S., and the late F. M. BALFOUR, F.R.S., Professor of Animal Morphology in the University of Cambridge. Second Edition, revised. Edited by A. SEDGWICK, M.A., Fellow and Assistant Lecturer of Trinity College, Cambridge, and W. HEAPE, M.A., late Demonstrator in the Morphological Laboratory of the University of Cambridge. Illustrated. Crown 8vo. 10s. 6d.

LESSONS IN ELEMENTARY BIOLOGY. By T. JEFFERY PARKER, F.R.S., Professor of Biology in the University of Otago, New Zealand. Illustrated. Second Edition. Crown 8vo. 10s. 6d.

A COURSE OF PRACTICAL INSTRUCTION IN ELEMENTARY BIOLOGY. By T. H. HUXLEY, F.R.S., assisted by H. N. MARTIN, F.R.S., Professor of Biology in the Johns Hopkins University, U.S.A. Third Edition, revised and extended by G. B. HOWES, Assistant Professor, Royal College of Science, and D. H. SCOTT, Ph.D. With a Preface by T. H. HUXLEY, F.R.S. Crown 8vo. 10s. 6d.

AN ATLAS OF PRACTICAL ELEMENTARY BIOLOGY. By G. B. HOWES, Assistant Professor, Royal College of Science, Lecturer on Comparative Anatomy, St. George's Medical School, London. With a Preface by T. H. HUXLEY, F.R.S. Medium 4to. 14s.

MACMILLAN AND CO., LONDON.